

# Lecture Notes in Control and Information Sciences 266

Stefano Stramigioli

## Modeling and IPC Control of Interactive Mechanical Systems: A Coordinate-free Approach



Springer

# Modeling And Ipc Control Of Interactive Mechanical Systems A Coordinatefree Approach

**Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo**



## **Modeling And Ipc Control Of Interactive Mechanical Systems A Coordinatefree Approach:**

**Modeling and IPC Control of Interactive Mechanical Systems - A Coordinate-Free Approach** Stefano Stramigioli, 2001-03-23 Robots and more generally mechanical systems are types of a physical system This is why it is important to study and control these systems using information about their particular structure that describes their particular nature In discussing physical systems concepts like energy interconnection and interaction become of substantial importance Furthermore during the modeling and control tasks the results we obtain should be independent from artificial coordinates that people use to analyse the results of their work This has lead to the concept of coordinate free description and tensors that have been used a lot in the theory of relativity Throughout this book emphasis is placed on the intrinsic description of the results reported The book describes the modeling and control of robotic systems subject to interaction It covers everything from basic concepts of differential geometry to real robotics Physics and the geometric interconnection of arts play a major role throughout the work

**Control of Interactive Robotic Interfaces** Cristian Secchi, Stefano Stramigioli, Cesare Fantuzzi, 2007-02-15 This monograph deals with energy based control of interactive robotic interfaces The port Hamiltonian framework is exploited both for modeling and controlling interactive robotic interfaces The book provides an energy oriented analysis and control synthesis of interactive robotic interfaces from a single robot to multi robot systems for interacting with real and virtual possibly unstructured environments

**Modeling and Control of Complex Physical Systems** Vincent Duindam, Alessandro Macchelli, Stefano Stramigioli, Herman Bruyninckx, 2009-10-15 Energy exchange is a major foundation of the dynamics of physical systems and hence in the study of complex multi domain systems methodologies that explicitly describe the topology of energy exchanges are instrumental in structuring the modeling and the computation of the system s dynamics and its control This book is the outcome of the European Project Geoplex FP5 IST 2001 34166 that studied and extended such system modeling and control methodologies This unique book starts from the basic concept of port based modeling and extends it to port Hamiltonian systems This generic paradigm is applied to various physical domains showing its power and unifying flexibility for real multi domain systems

**Modeling and Control for Efficient Bipedal Walking Robots** Vincent Duindam, Stefano Stramigioli, 2009-01-17 By the dawn of the new millennium robotics has undergone a major transformation in scope and dimensions This expansion has been brought about by the maturity of the field and the advances in its related technologies From a largely dominant industrial focus robotics has been rapidly expanding into the challenges of the human world The new generation of robots is expected to safely and dependably co habitat with humans in homes workplaces and communities providing support in services entertainment education health care manufacturing and assistance Beyond its impact on physical robots the body of knowledge robotics has produced is revealing a much wider range of applications reaching across diverse research areas and scientific disciplines such as biomechanics haptics neurosciences virtual simulation animation surgery and sensor networks among others In return the challenges of the new

emerging areas are providing an abundant source of stimulation and insights for the field of robotics. It is indeed at the intersection of disciplines that the most striking advances happen. The goal of the series of Springer Tracts in Advanced Robotics STAR is to bring in a timely fashion the latest advances and developments in robotics on the basis of their significance and quality. It is our hope that the wider dissemination of research developments will stimulate more exchanges and collaborations among the research community and contribute to further advancement of this rapidly growing field.

**Geometric Control of Mechanical Systems** Francesco Bullo, Andrew D. Lewis, 2019-06-12. The primary emphasis of this book is the modeling, analysis, and control of mechanical systems. The methods and results presented can be applied to a large class of mechanical control systems including applications in robotics, autonomous vehicle control, and multi-body systems. The book is unique in that it presents a unified rather than an inclusive treatment of control theory for mechanical systems. A distinctive feature of the presentation is its reliance on techniques from differential and Riemannian geometry. The book contains extensive examples and exercises and will be suitable for a growing number of courses in this area. It begins with the detailed mathematical background, proceeding through innovative approaches to physical modeling, analysis, and design techniques. Numerous examples illustrate the proposed methods and results, while the many exercises test basic knowledge and introduce topics not covered in the main body of the text. The audience of this book consists of two groups. The first group is comprised of graduate students in engineering or mathematical sciences who wish to learn the basics of geometric mechanics, nonlinear control theory, and control theory for mechanical systems. Readers will be able to immediately begin exploring the research literature on these subjects. The second group consists of researchers in mechanics and control theory. Nonlinear control theoreticians will find explicit links between concepts in geometric mechanics and nonlinear control theory. Researchers in mechanics will find an overview of topics in control theory that have relevance to mechanics. **PID**

**Trajectory Tracking Control for Mechanical Systems** Youngjin Choi, Wan Kyun Chung, 2004-01-23. Though PID control has a long history as much as its life force since Ziegler and Nichols published the empirical tuning rules in 1942, surprisingly it has never been changed in the structure itself. The strength of PID control lies in the simplicity, lucid meaning, and clear effect. Though it must be a widely accepted controller for mechanical control systems, it is still short of theoretical bases, e.g., optimality, performance tuning rules, automatic performance tuning method, and output feedback. PID control has not been clearly presented for mechanical control systems. These subjects will be thoroughly discussed in this book. There are many books of PID controller for the purpose of process control, but it is hard to find a book on the characteristics of PID control for mechanical systems. In the first place, when nonlinear optimal control theory is applied to mechanical systems, a class of Hamilton-Jacobi (HJ) equations is derived as a result of optimization. There are two methods to solve a class of HJ equations: a direct method using an approximation and an inverse method finding the performance index from a class of HJ equations. Also, there are two control methods according to the objective: the set point regulation control and trajectory tracking control. The

trajectory tracking control is basically different from set point regulation one in that the desired configuration velocity and acceleration profiles according to time progress are added to the motion of mechanical system This book is focusing on an inverse optimization method and the trajectory tracking control system      *Advanced Topics in Control Systems Theory* Françoise Lamnabhi-Lagarrigue, 2005-02-11 Advanced Topics in Control Systems Theory contains selected contributions written by lecturers at the second annual Formation d'Automatique de Paris FAP Graduate Control School in Paris It is addressed to graduate students and researchers in control theory with topics touching on a variety of areas of interest to the control community such as cascaded systems flatness optimal control and Hamiltonian and infinite dimensional systems The reader is provided with a well integrated synthesis of the latest thinking in these subjects without the need for an exhaustive literature review The internationally known contributors to this volume represent many of the most reputable control centers in Europe Advanced Topics in Control Systems Theory can be used to support either a one term general advanced course on nonlinear control theory devoting a few lectures to each chapter or for more focused and intensive courses at graduate level The book's concise but pedagogical manner will give an ideal start to researchers wishing to broaden their knowledge in aspects of modern control theory outside their own expertise      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      *Dynamics And Robust Control Of Robot-environment Interaction* Miomir Vukobratovic, Dragoljub Surdilovic, Yury Ekalo, Dusko Katic, 2009-03-06 This book covers the most attractive problem in robot control dealing with the direct interaction between a robot and a dynamic environment including the human robot physical interaction It provides comprehensive theoretical and experimental coverage of interaction control problems starting from the mathematical modeling of robots interacting with complex dynamic environments and proceeding to various concepts for interaction control design and implementation algorithms at different control layers Focusing on the learning principle it also shows the application of new and advanced learning algorithms for robotic contact tasks The ultimate aim is to strike a good balance between the necessary theoretical framework and practical aspects of interactive robots      **Nonlinear Control Systems 2004** Frank Allgower, Michael Zeitz, 2005-02-02      *Lagrangian and Hamiltonian Methods for Nonlinear Control* 2003 A Astolfi, Francisco Gordillo, A J Van Der Schaft, 2003-10-07 This is the second of a series of IFAC Workshops initiated in 2000 The first one chaired and organized by Profs N Leonard and R Ortega was held in Princeton in March 2000 This proceedings volume looks at the role played by Lagrangian and Hamiltonian methods in disciplines such as classical mechanics quantum mechanics fluid dynamics electrodynamics celestial mechanics and how such methods can be practically applied in the control community Presents and illustrates new approaches to nonlinear control that exploit the Lagrangian and Hamiltonian structure of the system to be controlled Highlights the important role of Lagrangian and Hamiltonian

Structures as design methods      *Perturbation Compensator based Robust Tracking Control and State Estimation of Mechanical Systems* SangJoo Kwon, Wan Kyun Chung, 2004-07-07 This monograph investigates a practical way to achieve robust motion control and state estimation Kalman filtering of mechanical systems which is a promising approach in terms of the perturbation compensator The book presents novel approaches for design and analysis of perturbation observers as well as an extension to robust motion control and robust state estimation The book is written in a self contained manner including experimental results in each chapter clearly validating the developed theories      New Trends in Nonlinear Dynamics and Control, and their Applications Wei Kang, Mingqing Xiao, Carlos Borges, 2003-09-16 A selection of papers exploring a wide spectrum of new trends in nonlinear dynamics and control such as bifurcation control state estimation and reconstruction analysis of behavior and stabilities dynamics of nonlinear neural network models and numerical algorithms The papers focus on new ideas and the latest developments in both theoretical and applied research topics of nonlinear control Because many of the authors are leading researchers in their own fields the papers presented in this volume reflect the state of the art in the areas of nonlinear dynamics and control Many of the papers in this volume were first presented at the highly successful Symposium on New Trends in Nonlinear Dynamics and Control and Their Applications held October 18 19 2002 in Monterey California      *Cartesian Impedance Control of Redundant and Flexible-Joint Robots* Christian Ott, 2008-07-22 By the dawn of the new millennium robotics has undergone a major transformation in scope and dimensions This expansion has been brought about by the maturity of the field and the advances in its related technologies From a largely dominant industrial focus robotics has been rapidly expanding into the challenges of the human world The new generation of robots is expected to safely and dependably co-habitat with humans in homes workplaces and communities providing support in services entertainment education healthcare manufacturing and assistance Beyond its impact on physical robots the body of knowledge robotics has produced is revealing a much wider range of applications reaching across diverse research areas and scientific disciplines such as biomechanics haptics neurosciences virtual simulation animation surgery and sensor networks among others In return the challenges of the new emerging areas are proving an abundant source of stimulation and insights for the field of robotics It is indeed at the intersection of disciplines that the most striking advances happen The goal of the series of Springer Tracts in Advanced Robotics STAR is to bring in a timely fashion the latest advances and developments in robotics on the basis of their significance and quality It is our hope that the wider dissemination of research developments will stimulate more exchanges and collaborations among the research community and contribute to further advancement of this rapidly growing field      **Robotics** Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, 2010-08-20 Based on the successful *Modelling and Control of Robot Manipulators* by Sciavicco and Siciliano Springer 2000 *Robotics* provides the basic know-how on the foundations of robotics modelling planning and control It has been expanded to include coverage of mobile robots visual control and motion planning A variety of problems is raised throughout and the proper tools to find engineering

oriented solutions are introduced and explained The text includes coverage of fundamental topics like kinematics and trajectory planning and related technological aspects including actuators and sensors To impart practical skill examples and case studies are carefully worked out and interwoven through the text with frequent resort to simulation In addition end of chapter exercises are proposed and the book is accompanied by an electronic solutions manual containing the MATLAB code for computer problems this is available free of charge to those adopting this volume as a textbook for courses

*Optimal Control, Stabilization and Nonsmooth Analysis* Marcio S. de Queiroz, Michael Malisoff, Peter Wolenski, 2004-04-20 This edited book contains selected papers presented at the Louisiana Conference on Mathematical Control Theory MCT 03 which brought together over 35 prominent world experts in mathematical control theory and its applications The book forms a well integrated exploration of those areas of mathematical control theory in which nonsmooth analysis is having a major impact These include necessary and sufficient conditions in optimal control Lyapunov characterizations of stability input to state stability the construction of feedback mechanisms viscosity solutions of Hamilton Jacobi equations invariance approximation theory impulsive systems computational issues for nonlinear systems and other topics of interest to mathematicians and control engineers The book has a strong interdisciplinary component and was designed to facilitate the interaction between leading mathematical experts in nonsmooth analysis and engineers who are increasingly using nonsmooth analytic tools

**Vehicle-Manipulator Systems** Pål Johan From, Jan Tommy Gravdahl, Kristin Ytterstad Pettersen, 2013-10-02 Furthering the aim of reducing human exposure to hazardous environments this monograph presents a detailed study of the modeling and control of vehicle manipulator systems The text shows how complex interactions can be performed at remote locations using systems that combine the manipulability of robotic manipulators with the ability of mobile robots to locomote over large areas The first part studies the kinematics and dynamics of rigid bodies and standard robotic manipulators and can be used as an introduction to robotics focussing on robust mathematical modeling The monograph then moves on to study vehicle manipulator systems in great detail with emphasis on combining two different configuration spaces in a mathematically sound way Robustness of these systems is extremely important and Modeling and Control of Vehicle manipulator Systems effectively represents the dynamic equations using a mathematically robust framework Several tools from Lie theory and differential geometry are used to obtain globally valid representations of the dynamic equations of vehicle manipulator systems The specific characteristics of several different types of vehicle manipulator systems are included and the various application areas of these systems are discussed in detail For underwater robots buoyancy and gravity drag forces added mass properties and ocean currents are considered For space robotics the effects of free fall environments and the strong dynamic coupling between the spacecraft and the manipulator are discussed For wheeled robots wheel kinematics and non holonomic motion is treated and finally the inertial forces are included for robots mounted on a forced moving base Modeling and Control of Vehicle manipulator Systems will be of interest to researchers and

engineers studying and working on many applications of robotics underwater space personal assistance and mobile manipulation in general all of which have similarities in the equations required for modeling and control

*Control Reconfiguration of Dynamical Systems* Thomas Steffen, 2005-08-31 Reconfiguration an approach for fault tolerant control involves changing the control structure in response to the fault This monograph extends this idea to actuator faults and studies in detail the so called virtual actuator approach Control Reconfiguration of Dynamical Systems also introduces structural analysis as a tool for reconfiguration Because a fault changes the structure of the system the reconfiguration solution is sought on a structural level Novel algorithms are presented to test for reconfigurability and to find a reconfiguration solution A MATLAB toolbox is supplied which contains the main algorithms and examples The book addresses advanced engineering students developers and researchers that have a specific interest in control reconfiguration

**Mathematical Control Theory I** M. Kanat Camlibel, A. Agung Julius, Ramkrishna Pasumathy, Jacqueliene M.A. Scherpen, 2015-07-15 This treatment of modern topics related to mathematical systems theory forms the proceedings of a workshop Mathematical Systems Theory From Behaviors to Nonlinear Control held at the University of Groningen in July 2015 The workshop celebrated the work of Professors Arjan van der Schaft and Harry Trentelman honouring their 60th Birthdays The first volume of this two volume work covers a variety of topics related to nonlinear and hybrid control systems After giving a detailed account of the state of the art in the related topic each chapter presents new results and discusses new directions As such this volume provides a broad picture of the theory of nonlinear and hybrid control systems for scientists and engineers with an interest in the interdisciplinary field of systems and control theory The reader will benefit from the expert participants ideas on exciting new approaches to control and system theory and their predictions of future directions for the subject that were discussed at the workshop

**Advances in Communication Control Networks** Sophie Tarbouriech, Chaouki T. Abdallah, John Chiasson, 2004-09-22 The area of communication and computer networks has become a very active field of research by the control systems community in the last years Tools from convex optimization and control theory are playing increasing roles in efficient network utilization fair resource allocation and communication delay accommodation and the field of Networked Control systems is fast becoming a mainstay of control systems research and applications This carefully edited book brings together solicited contributions from experts in the various areas of communication control networks referring to both networks under control control in networks as well as networked control systems control over networks The aim of this book is to reverse the trend of fragmentation and specialization in Communication Control Networks connecting various interdisciplinary research fields including control communication applied mathematics and computer science



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