

**Nonlinear Control of Underactuated Mechanical
Systems with Application to Robotics and
Aerospace Vehicles**

by

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Nonlinear Control For Underactuated Mechanical Systems

RC Schank

Nonlinear Control For Underactuated Mechanical Systems:

Non-linear Control for Underactuated Mechanical Systems Isabelle Fantoni, Rogelio Lozano, 2002 This book deals with the application of modern control theory to some important underactuated mechanical systems. It presents modelling and control of the following systems: the inverted pendulum, a convey crane system, the pendubot system, the Furuta pendulum, the inertia wheel pendulum, the planar flexible joint robot, the planar manipulator with two prismatic and one revolute joints, the ball, the hovercraft model, the planar vertical and take off landing PVTOL aircraft, the helicopter model on a platform, the helicopter model. In every case the model is obtained in detail using either the Euler-Lagrange formulation or the Newton's second law. The text develops control algorithms for every particular system using techniques such as passivity, energy based Lyapunov functions, forwarding, backstepping or feedback linearization techniques. This book is designed for PhD students and researchers in the areas of non linear control systems, mechanical systems, robotics and control of helicopters. It will help the reader gain experience in the modelling of mechanical systems and familiarize with new control methods for non linear systems.

Nonlinear Control of Underactuated Mechanical Systems with Application to Robotics and Aerospace Vehicles Reza Olfati-Saber, 2001

Control of Underactuated Mechanical Systems Afef Hfaiedh, Ahmed

Chemori, 2025-04-01 Control of Underactuated Mechanical Systems Stabilization and Limit Cycle Generation clearly explains stabilization and limit cycle generation in underactuated mechanical systems (UMS) addressing control design challenges and demonstrating concepts through real time experiments. The book begins with advancements in UMS introducing key concepts such as stabilization and limit cycle generation supported by literature examples. It then focuses on the inertia wheel, inverted pendulum presenting a detailed discussion. The second part tackles stabilization offering various control solutions validated through numerical simulations and real time experiments. The final part addresses stable limit cycle generation detailing three proposed control solutions and their validation through different case studies. This book is a valuable resource for PhD and Master students, engineers, researchers and educators. It provides guidance in robotics and automatic control utilizing a simplified methodology for controlling underactuated mechanical systems. Addresses stabilization and stable limit cycle generation in underactuated mechanical systems amid perturbations. Explores the design, development and validation of robust control solutions. Illustrates concepts through case studies. Validates control solutions with numerical simulations and real time experiments.

Analysis and Control of Underactuated Mechanical Systems Amal

Choukchou-Braham, Brahim Cherki, Mohamed Djemaï, Krishna Busawon, 2013-11-18 This monograph provides readers with tools for the analysis and control of systems with fewer control inputs than degrees of freedom to be controlled i.e. underactuated systems. The text deals with the consequences of a lack of a general theory that would allow methodical treatment of such systems and the ad hoc approach to control design that often results in imposing a level of organization whenever the latter is lacking. The authors take as their starting point the construction of a graphical characterization or

control flow diagram reflecting the transmission of generalized forces through the degrees of freedom Underactuated systems are classified according to the three main structures by which this is found to happen chain tree and isolated vertex and control design procedures proposed The procedure is applied to several well known examples of underactuated systems acrobot pendubot Tora system ball and beam inertia wheel and robotic arm with elastic joint The text is illustrated with MATLAB^{sup} Simulink simulations that demonstrate the effectiveness of the methods detailed ppReaders interested in aircraft vehicle control or various forms of walking robot will be able to learn from iUnderactuated Mechanical Systems

Motion Control of Underactuated Mechanical Systems Javier Moreno-Valenzuela, Carlos Aguilar-Avelar, 2017-07-11 This volume is the first to present a unified perspective on the control of underactuated mechanical systems Based on real time implementation of parameter identification this book provides a variety of algorithms for the Furuta pendulum and the inertia wheel pendulum which are two degrees of freedom mechanical systems Specifically this work addresses and solves the problem of motion control via trajectory tracking in one joint coordinate while another joint is regulated Besides discussions on extensions to higher degrees of freedom systems are given The book aimed at control engineers as well as graduate students ranges from the problem of parameter identification of the studied systems to the practical implementation of sophisticated motion control algorithms Offering real world solutions to manage the control of underactuated systems this book provides a concise tutorial on recent breakthroughs in the field original procedures to achieve bounding of the error trajectories convergence and gain tuning guidelines

Block Backstepping Design of Nonlinear State Feedback Control Law for Underactuated Mechanical Systems Shubhobrata Rudra, Ranjit Kumar Barai, Madhubanti Maitra, 2016-09-08

This book presents a novel generalized approach to the design of nonlinear state feedback control laws for a large class of underactuated mechanical systems based on application of the block backstepping method The control law proposed here is robust against the effects of model uncertainty in dynamic and steady state performance and addresses the issue of asymptotic stabilization for the class of underactuated mechanical systems An underactuated system is defined as one for which the dimension of space spanned by the configuration vector is greater than that of the space spanned by the control variables Control problems concerning underactuated systems currently represent an active field of research due to their broad range of applications in robotics aerospace and marine contexts The book derives a generalized theory of block backstepping control design for underactuated mechanical systems and examines several case studies that cover interesting examples of underactuated mechanical systems The mathematical derivations are described using well known notations and simple algebra without the need for any special previous background in higher mathematics The chapters are lucidly described in a systematic manner starting with control system preliminaries and moving on to a generalized description of the block backstepping method before turning to several case studies Simulation and experimental results are also provided to aid in reader comprehension

Nonlinear Systems Nathan van de

Wouw,Erjen Lefeber,Ines Lopez Arteaga,2016-07-07 This treatment of modern topics related to the control of nonlinear systems is a collection of contributions celebrating the work of Professor Henk Nijmeijer and honoring his 60th birthday It addresses several topics that have been the core of Professor Nijmeijer's work namely the control of nonlinear systems geometric control theory synchronization coordinated control convergent systems and the control of underactuated systems The book presents recent advances in these areas contributed by leading international researchers in systems and control In addition to the theoretical questions treated in the text particular attention is paid to a number of applications including mobile robotics marine vehicles neural dynamics and mechanical systems generally This volume provides a broad picture of the analysis and control of nonlinear 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 important open problems with contributions that represent the state of the art in nonlinear control

Noise Coupling in System-on-chip Thomas Noulis,Yong-Duan Song,2018

The Nonlinear Control Theory of Complex Mechanical Systems ,1998 This report summarizes a body of research dealing with the nonlinear control theory of complex mechanical systems The principal focus is on so called superarticulated or underactuated mechanical systems and systems having a mixture of directly controlled as well as uncontrolled degrees of freedom The two fold goal of the research is 1 how to control the degrees of freedom which are directly actuated without eliciting undesired behavior in the unactuated degrees of freedom and 2 how to prescribe motions of the directly actuated degrees of freedom which are not directly controlled The report contains a comprehensive list of research published under this grant as well as some predecessor grants Two papers in particular The Geometry of Controlled Mechanical Systems and Open loop Oscillatory Stabilization of an n Pendulum comprise the present report

Control of Ships and Underwater Vehicles Khac Duc Do,Jie Pan,2009-08-09 Most ocean vessels are underactuated but control of their motion in the real ocean environment is essential Starting with a review of the background on ocean vessel dynamics and nonlinear control theory the authors systematic approach is based on various nontrivial coordinate transformations coupled with advanced nonlinear control design methods This strategy is then used for the development and analysis of a number of ocean vessel control systems with the aim of achieving advanced motion control tasks including stabilization trajectory tracking path tracking and path following Control of Ships and Underwater Vehicles offers the reader new results in the nonlinear control of underactuated ocean vessels efficient designs for the implementation of controllers on underactuated ocean vessels numerical simulations and real time implementations of the control systems designed on a scale model ship for each controller developed to illustrate their effectiveness and afford practical guidance

Nonlinear Control of Underactuated Horizontal Double Pendulum Cristian Popescu,2002

Nonlinear Control Systems Design, 1998 ,1998

Advances in Systems Science Jerzy Świątek,Adam Grzech,Paweł Świątek,Jakub M. Tomczak,2013-08-13 The International Conference on Systems Science 2013 ICSS 2013 was the 18th event of the series of

international scientific conferences for researchers and practitioners in the fields of systems science and systems engineering The conference took place in Wroclaw Poland during September 10 12 2013 and was organized by Wroclaw University of Technology and co organized by Committee of Automatics and Robotics of Polish Academy of Sciences Committee of Computer Science of Polish Academy of Sciences and Polish Section of IEEE The papers included in the proceedings cover the following topics Control Theory Databases and Data Mining Image and Signal Processing Machine Learning Modeling and Simulation Operational Research Service Science Time series and System Identification The accepted and presented papers highlight new trends and challenges in systems science and systems engineering Nonlinear And Adaptive Control: Tools And Algorithms For The User Alessandro Astolfi,2005-12-15 This book summarizes the main results achieved in a four year European Project on nonlinear and adaptive control The project involves leading researchers from top notch institutions Imperial College London Prof A Astolfi Lund University Prof A Rantzer Supelec Paris Prof R Ortega University of Technology of Compiegne Prof R Lozano Grenoble Polytechnic Prof C Canudas de Wit University of Twente Prof A van der Schaft Politecnico of Milan Prof S Bittanti and Polytechnic University of Valencia Prof P Albertos The book also provides an introduction to theoretical advances in nonlinear and adaptive control and an overview of novel applications of advanced control theory particularly topics on the control of partially known systems under actuated systems and bioreactors

a **Dynamics and Control of Underactuated Multibody Spacecraft** Sangbum Cho,2002 The latter part of this dissertation presents results of control problems for several underactuated multibody spacecraft examples These include spacecraft with an unactuated internal sliding mass spacecraft with unactuated fuel slosh dynamics tethered spacecraft with attachment point actuation and the triaxial attitude control testbed with two proof mass actuation devices These examples illustrate important features related to the dynamics and control of various underactuated multibody spacecraft Differences in geometries of the spacecraft and gravitational assumptions require adoption of different types of control schemes We use the multibody equations in this dissertation to formulate control equations for the models and to construct feedback controllers that achieves asymptotic stability or convergence to the desired relative equilibrium manifolds Computer simulations demonstrate the effectiveness of the controllers *2011 International Conference in Electrics, Communication and Automatic Control Proceedings* Ran Chen,2011-11-25 2011 International Conference in Electrics Communication and Automatic Control Proceedings examines state of art and advances in Electrics Communication and Automatic Control This book presents developments in Power Conversion Signal and image processing Image video Signal Processing The conference brings together researchers engineers academic as well as industrial professionals from all over the world to promote the developments of Electrics Communication and Automatic Control **Model-Based Tracking Control of Nonlinear Systems** Elzbieta Jarzbowska,2012-07-17 Model Based Control of Nonlinear Systems presents model based control techniques for nonlinear constrained systems It covers constructive control design methods with an emphasis on

modeling constrained systems generating dynamic control models and designing tracking control algorithms for the models. The book's interdisciplinary approach illustrates how system modeling and control theory are essential to control design projects. Organized according to the steps in a control design project the text first discusses kinematic and dynamic modeling methods including programmed constraints Lagrange's equations Boltzmann Hamel equations and generalized programmed motion equations. The next chapter describes basic control concepts and the use of nonlinear control theory. After exploring stabilization strategies for nonlinear systems the author presents existing model based tracking control algorithms and path following strategies for nonlinear systems. The final chapter develops a new model reference tracking strategy for programmed motion. Throughout the text two examples of mechanical systems are used to illustrate the theory and simulation results. The first example is a unicycle model nonholonomic system and the second is a two link planar

manipulator model holonomic system. With a focus on constructive modeling and control methods this book provides the tools and techniques to support the control design process.

Computer Aided Systems Theory -- EUROCAST 2013

Roberto Moreno-Díaz, Franz Pichler, Alexis Quesada-Arencibia, 2013-12-12. The two volume set LNCS 8111 and LNCS 8112 constitute the papers presented at the 14th International Conference on Computer Aided Systems Theory EUROCAST 2013 held in February 2013 in Las Palmas de Gran Canaria Spain. The total of 131 papers presented were carefully reviewed and selected for inclusion in the books. The contributions are organized in topical sections on modelling biological systems systems theory and applications intelligent information processing theory and applications of metaheuristic algorithms model based system design verification and simulation process modeling simulation and system optimization mobile and autonomous

transportation systems computer vision sensing image processing and medical applications computer based methods and virtual reality for clinical and academic medicine digital signal processing methods and applications mechatronic systems robotics and marine robots mobile computing platforms and technologies systems applications

Proceedings of the ...

SICE Annual Conference Keisoku Jidō Seigyo Gakkai (Japan). Gakujutsu Kōenkai, 2004. **Proceedings of the ... American Control Conference**, 2005

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