Control Of Nonlinear Multibody Flexible Space Structures Lecture Notes In Control And Information Sciences

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Robust Control of Nonlinear Flexible Multibody Systems Using Quaternion Feedback And, Atul G. Kelkar Et Al NASA, Langley Research Center, April 1994
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EILEEN WALLS

Dynamics of Multibody Systems Academic Press
The problem of controlling a class of nonlinear multibody flexible space systems consisting of a flexible central body to which a number of articulated appendages are attached is considered. Collocated actuators and sensors are assumed, and global asymptotic stability of such systems is established under a nonlinear dissipative control law. The stability is shown to be robust to unmodeled dynamics and parametric uncertainties. For a special case in which the attitude motion of the central body is small, the system, although still nonlinear, is shown to be stabilized by linear dissipative control laws. Two types of linear controllers are considered: static dissipative (constant gain) and dynamic dissipative. The static dissipative control law is also shown to provide robust stability in the presence of certain classes of actuator and sensor nonlinearities and actuator dynamics. The results obtained for this special case can also be readily applied for controlling single-body linear flexible space structures. For this case, a synthesis technique for the design of a suboptimal dynamic dissipative controller is also presented. The results obtained in this paper are applicable to a broad class of multibody and single-body systems such as flexible multilink manipulators, multipayload space platforms, and space antennas. The stability proofs use the Lyapunov approach and exploit the inherent passivity of such systems. Joshi, Suresh M. and Kelkar, Atul G. and Maghami, Peiman G. Langley Research Center RTOP 233-01-01-05...
Multibody Dynamics Routledge
This book is the result of over ten (10) years of research and development in flexible robots and structures at Sandia National Laboratories. The authors de cided to collect this wealth of knowledge into a set of viewgraphs in order to teach a graduate class in Flexible Robot Dynamics and Controls within the Mechanical En gineering Department at the University of New Mexico (UNM). These viewgraphs, encouragement from several students, and many late nights have produced a book that should provide an upper-level undergraduate and graduate textbook and a reference for experienced professionals. The content of this book spans several disciplines including structural dynam ics, system identification, optimization, and linear, digital, and nonlinear control theory which are developed from several points of view including electrical, me chanical, and aerospace engineering as well as engineering mechanics. As a result, the authors believe that this book demonstrates the value of solid applied theory when developing hardware solutions to real world problems. The reader will find many real world applications in this book and will be shown the applicability of these techniques beyond flexible structures which, in turn, shows the value of mul tidisciplinary education and teaming.
Smart Materials and Structures Springer Science & Business Media
Control of Nonlinear Multibody Flexible Space StructuresSpringer
Modern Flexible Multi-Body Dynamics Modeling Methodology for Flapping Wing Vehicles Createspace Independent Publishing Platform
This book presents a novel theory of multibody dynamics with distinct features, including unified continuum theory, multiscale modeling technology of multibody system, and motion formalism implementation. All these features together with the introductions of fundamental concepts of vector, dual vector, tensor, dual tensor, recursive descriptions of joints, and the higher-order implicit solvers formulate the scope of the book’s content. In this book, a multibody system is defined as a set consisted of flexible and rigid bodies which are connected by any kinds of joints or constraints to achieve the desired motion. Generally, the motion of multibody system includes the translation and rotation; it is more efficient to describe the motion by using the dual vector or dual tensor directly instead of defining two types of variables, the translation and rotation separately. Furthermore, this book addresses the detail of motion formalism and its finite element implementation of the solid, shell-like, and beam-like structures. It also introduces the fundamental concepts of mechanics, such as the definition of vector, dual vector, tensor, and dual tensor, briefly. Without following the Einstein summation convention, the first- and second-order tensor operations in this book are depicted by linear algebraic operation symbols of row array, column array, and two-dimensional matrix, making these operations easier to understand. In addition, for the integral of governing equations of motion, a set of ordinary differential equations for the finite element-based discrete system, the book discussed the implementation of implicit solvers in detail and introduced the well-developed RADAU IIA algorithms based on post-error estimation to make the contents of the book complete. The intended readers of this book are senior engineers and graduate students in related engineering fields.
Springer Nature
With the advances made in computer technology and efficiency of numerical algorithms over last decade, the MPC strategies have become quite popular among control community. However, application of MPC or GPC to flexible space structure control has not been explored adequately in the literature. The work presented in this thesis primarily focuses on application of GPC to control of nonlinear flexible space structures. This thesis is particularly devoted to the development of various approximate dynamic models, design and assessment of candidate controllers, and extensive numerical simulations for a realistic multibody flexible spacecraft, namely, Jupiter Icy Moons Orbiter (JIMO) - a Prometheus class of spacecraft proposed by NASA for deep space exploratory missions. A stable GPC algorithm is developed for Multi-Input-Multi-Output (MIMO) systems. An end-point weighting (penalty) is used in the GPC cost function to guarantee the nominal stability of the closed-loop system. A method is given to compute the desired end-point state from the desired output trajectory. The methodologies based on Fake Algebraic Riccati Equation (FARE) and constrained nonlinear optimization, are developed for synthesis of state weighting matrix. This makes this formulation more practical. A stable reconfigurable GPC architecture is presented and its effectiveness is demonstrated on both aircraft as well as spacecraft model. A representative in-orbit maneuver is used for assessing the performance of various control strategies using various design models. Different approximate dynamic models used for analysis include linear single body flexible structure, nonlinear single body flexible structure, and nonlinear multibody flexible structure. The control laws evaluated include traditional GPC, feedback linearization-based GPC (FLGPC), reconfigurable GPC, and nonlinear dissipative control. These various control schemes are evaluated for robust stability and robust performance in the presence of parametric uncertainties and input disturbances. Finally, the conclusions are made with regard to the efficacy of these controllers and potential directions for future research.
Control of Nonlinear Multibody Flexible Space Structures Springer Science & Business Media
The unprecedented requirements for rapid retargeting and precision pointing for spaced-based directed energy weapon platforms is the prime driver behind the reported modeling and control study. The combination of such requirements demand a comprehensive dynamic model of the nonlinear multibody dynamics of typical space platforms for such weapon including the interaction platform structural flexure effecting principal weapon system effective Line-Of-Sight. This report describes the first year effort of a three year project which focuses on: (1) the development of comprehensive; generic nonlinear dynamical models for typical space-based plat forms, (2) the development of high performance, nonlinear control laws for rapid slewing and precesion pointing of

primary weapon system payload apertures, and (3) the design of a series of laboratory experiments to verify and test the control laws developed. The validation of the analytical models and the required control theory for the resulting class of nonlinear system is described in this report. Simulation results are given for a simplified benchmark model of a space-based laser slewing control and consideration for compensation for structural flexure effecting optical LOS using optical steering mirrors is discussed. (sdw).

Finite-Spectrum Assignment for Time-Delay Systems Springer

This book presents iterative learning control (ILC) to address practical issues of flexible structures. It is divided into four parts: Part I provides a general introduction to ILC and flexible structures, while Part II proposes various types of ILC for simple flexible structures to address issues such as vibration, input saturation, input dead-zone, input backlash, external disturbances, and trajectory tracking. It also includes simple partial differential equations to deal with the common problems of flexible structures. Part III discusses the design of ILC for flexible micro aerial vehicles and two-link manipulators, and lastly, Part IV offers a summary of the topics covered. Unlike most of the literature on ILC, which focuses on ordinary differential equation systems, this book explores distributed parameter systems, which are comparatively less stabilized through ILC.Including a comprehensive introduction to ILC of flexible structures, it also examines novel approaches used in ILC to address input constraints and disturbance rejection. This book is intended for researchers, graduate students and engineers in various fields, such as flexible structures, external disturbances, nonlinear inputs and tracking control.

Dynamics of Underactuated Multibody Systems CRC Press

The ECCOMAS Thematic Conference “Multibody Dynamics 2009” was held in Warsaw, representing the fourth edition of a series which began in Lisbon (2003), and was then continued in Madrid (2005) and Milan (2007), held under the auspices of the European Community on Computational Methods in Applied Sciences (ECCOMAS). The conference provided a forum for exchanging ideas and results of several topics related to computational methods and applications in multibody dynamics, through the participation of 219 scientists from 27 countries, mostly from Europe but also from America and Asia. This book contains the revised and extended versions of invited conference papers, reporting on the state-of-the-art in the advances of computational multibody models, from the theoretical developments to practical engineering applications. By providing a helpful overview of the most active areas and the recent efforts of many prominent research groups in the field of multibody dynamics, this book can be highly valuable for both experienced researches who want to keep updated with the latest developments in this field and researches approaching the field for the first time.

Multiscale Multibody Dynamics Springer Nature

Arun K. Banerjee is one of the foremost experts in the world on the subject of flexible multibody dynamics. This book describes how to build mathermatical models of multibody systems with elastic components. Examples of such systems include the human body itself, construction cranes, cares with trailers, helicopers, spacecraft deploying antennas, tethered satellites, and underwater maneuvering vehicles. This book provides methods of analysis of complex mechanical systems that can be simulated in less computer time than other methods. It equips the reader with knowledge of algorithms that provide accurate results in reduced simulation time.

Nonlinear Coupling Between Control and Dynamic Parameters in Flexible Multibody Dynamics Cambridge University Press

This book contains an edited versIOn of lectures presented at the NATO ADVANCED STUDY INSTITUTE on VIRTUAL NONLINEAR MUL TIBODY SYSTEMS which was held in Prague, Czech Republic, from 23 June to 3 July 2002. It was organized by the Department of Mechanics, Faculty of Mechanical Engineering, Czech Technical University in Prague, in cooperation with the Institute B of Mechanics, University of Stuttgart, Germany. The ADVANCED STUDY INSTITUTE addressed the state of the art in multibody dynamics placing special emphasis on nonlinear systems, virtual reality, and control design as required in mechatronics and its corresponding applications. Eighty-six participants from twenty-two countries representing academia, industry, government and research institutions attended the meeting. The high qualification of the participants contributed greatly to the success of the ADVANCED STUDY INSTITUTE in that it promoted the exchange of experience between leading scientists and young scholars, and encouraged discussions to generate new ideas and to define directions of research and future developments. The full program of the ADVANCED STUDY INSTITUTE included also contributed presentations made by participants where different topics were explored, among them: Such topics include: nonholonomic systems; flexible multibody systems; contact, impact and collision; numerical methods of differential-algebraical equations; simulation approaches; virtual modelling; mechatronic design; control; biomechanics; space structures and vehicle dynamics. These presentations have been reviewed and a selection will be published in this volume, and in special issues of the journals Multibody System Dynamics and Mechanics of Structures and Machines.

IUTAM Symposium on Intelligent Multibody Systems – Dynamics, Control, Simulation Springer Science & Business Media

These papers were presented at the first EC-TMR Nonlinear Control Network Workshop, on Stability and Stabilization of Nonlinear Systems, that took place in March 1999, Ghent, Belgium. The TMR programme offers a unique opportunity for the academic community to expand their knowledge, share their experience and identify and discuss strategic issues in aspects of nonlinear control engineering. The aim is to create a resource centre of available expertise and research interests. This outstanding reference volume presents current and emerging research directions, including: Stability analysis of nonlinear dynamical systems and converse Lyapunov theorems; Stabilization and regulation of nonlinear dynamical control systems; Control of physical systems using physics-based Lyapunov functions and passivity, as well as bifurcation analysis and optimal control. This collection of peer-reviewed papers provides a comprehensive overview of this field of research for graduate students and researchers in engineering and applied mathematics.

Flexible Robot Dynamics and Controls American Society of Mechanical Engineers

Addressing the difficult problem of controlling flexible spacecraft having multiple articulated appendages is the aim of this volume. Such systems are needed for space mission concepts including multi-payload space platforms and autonomous space-based manipulators. These systems are characterised by highly nonlinear dynamics, flexibility in members and joints, low inherent damping, and modeling uncertainty. A complete nonlinear rotational dynamic model of a generic multibody flexible system is derived, and is shown to possess certain passivity properties. The main result is a class of passivity-based nonlinear and linear output feedback control laws that enable globally stable closed-loop manoeuvres. The control laws are robust to parametric uncertainties, unmodeled uncertainties, and in some cases, actuator and sensor nonlinearities. All results given are also applicable to flexible terrestrial manipulators.

Flexible Multibody Dynamics Springer

This volume, which brings together research presented at the IUTAM Symposium Intelligent Multibody Systems – Dynamics, Control, Simulation, held at Sozopol, Bulgaria, September 11-15, 2017, focuses on preliminary virtual simulation of the dynamics of motion, and analysis of loading of the devices and of their behaviour caused by the working conditions and natural phenomena. This requires up-to-date methods for dynamics analysis and simulation, novel methods for numerical solution of ODE and DAE, real-time simulation, passive, semi-passive and active control algorithms. Applied examples are mechatronic (intelligent) multibody systems, autonomous vehicles, space structures, structures exposed to external and seismic excitations, large flexible structures and wind generators, robots and bio-robots. The book covers the following subjects: -Novel methods in multibody system dynamics; -Real-time dynamics; -Dynamic models of passive and active mechatronic devices; -Vehicle dynamics and control; -Structural dynamics; -Deflection and vibration suppression; -Numerical integration of ODE and DAE for large scale and stiff multibody systems; -Model reduction of large-scale flexible systems. The book will be of interest for scientists and academicians, PhD students and engineers at universities and scientific institutes.

NASA Technical Memorandum Springer

The volume contains 19 contributions by international experts in the field of multibody system dynamics, robotics and control. The book aims to bridge the gap between the modeling of mechanical systems by means of multibody dynamics formulations and robotics. In the classical approach, a multibody dynamics model contains a very high level of detail, however, the application of such models to robotics or control is usually limited. The papers aim to connect the different scientific communities in multibody dynamics, robotics and control. Main topics are flexible multibody systems, humanoid robots, elastic robots, nonlinear control, optimal path planning, and identification.

Stability and Stabilization of Nonlinear Systems Springer

This book contains the edited version of the lectures presented at the NATO ADVANCED STUDY INSTITUTE on "COMPUTER AIDED ANALYSIS OF RIGID AND FLEXIBLE MECHANICAL SYSTEMS". held in Troia. Portugal. from the 27 June to 9 July. 1993. and organized by the Instituto de Engenharia Mecanica. Instituto Superior Tecnico. This ASI addressed the state-of-art in the field of multibody dynamics. which is now a well developed subject with a great variety of formalisms. methods and principles. Ninety five participants. from twenty countries. representing academia. industry. government and research institutions attended this Institute. This contributed greatly to the success of the Institute since it encouraged the interchange of experiences between leading scientists and young scholars and promoted discussions that helped to generate new ideas and to defme directions of research and future developments. The full program of the Institute included also contributed presentations made by participants where different topics have been explored. Such topics include: formulations and numerical aspects in rigid and flexible mechanical systems; object-oriented paradigms; optimal design and synthesis; robotics; kinematics; path planning; control; impact dynamics; and several application oriented developments in weapon systems. vehicles and crash worthiness. These papers have been revised and will be published by Kluwer in a special issue of the Journal of Nonlinear Dynamics and in a forthcoming companion book. This book brings together. in a tutorial and review manner. a comprehensive summary of current work and is therefore suitable for a wide range of interests.

A Class of Stabilizing Controllers for Flexible Multibody Systems Springer

The development and launch of the first artificial satellite Sputnik more than five decades ago propelled both the scientific and engineering communities to new heights as they worked together to develop novel solutions to the challenges of spacecraft system design. This symbiotic relationship has brought significant technological advances that have enabled the design of systems that can withstand the rigors of space while providing valuable space-based services. With its 26 chapters divided into three sections, this book brings together critical contributions from renowned international researchers to provide an outstanding survey of recent advances in spacecraft technologies. The first section includes nine chapters that focus on innovative hardware technologies while the next section is comprised of seven chapters that center on cutting-edge state estimation techniques. The final section contains eleven chapters that present a series of novel control methods for spacecraft orbit and attitude control.

Large Space Structures & Systems in the Space Station Era John Wiley & Sons

This book is an essential guide to nonlinear dynamics and vibration control, detailing both the theory and the practical industrial applications within all aspects of engineering. Demonstrating how to improve efficiency through reducing unwanted vibration, it will aid both students and engineers in practically and safely improving flexible structures through control methods. Increasing demand for light-weight robotic systems and space applications has actuated the design and construction of more flexible structures. These flexible structures, involving numerous dynamic systems, experience unwanted vibrations, impacting accuracy, operating speed, safety and, importantly, efficiency. This book aids engineers in assuaging this issue through vibration control methods, including nonlinear dynamics. It covers topics such as dynamic modeling of nonlinear system, nonlinear oscillators, and modal analyses of multiple-mode system. It also looks at vibration control methods including linear control, nonlinear control, intelligent control, and command smoothers. These control methods are effective and reliable methods to counteract unwanted vibrations. The book is practically minded, using industrial applications throughout, such as bridge cranes, tower cranes, aerial cranes and liquid sloshing. It also discusses cable-suspension structures, light-weight links, and fluid motions which exhibit flexible-structure dynamics. The book will be of interest to students and engineers alike, in the field of mechatronics, mechanical systems and signal processing, nonlinear dynamics, vibration, and control engineering.

Control of Nonlinear Flexible Space Structures Springer Nature

This book provides a comprehensive review of fundamental issues in the dynamical modeling and vibration control design for several flexible mechanical systems, such as flexible satellites, flexible aerial refueling hoses, and flexible three-dimensional manipulators. Offering an authoritative reference guide to the dynamics and control of flexible mechanical systems, it equips readers to solve a host of problems concerning these systems. It provides not only a complete overview of flexible systems, but also a better understanding of the technical levels involved. The book is divided into ten chapters: Chapters 1 and 2 lay the foundations, while the remaining chapters explore several independent yet related topics in detail. The book’s final chapter presents conclusions and recommendations for future research. Given its scope, the book is intended for researchers, graduate students, and engineers whose work involves control systems, flexible mechanical systems, and related areas.

Nonlinear Dynamics and Vibration Control of Flexible Systems Springer Science & Business Media

Dieses Lehrbuch gibt eine anschauliche Einführung in die Theorie und Anwendung nichtlinearer Systeme und Regelungen. Der Autor stellt die in Forschung und industrieller Anwendung immer wichtiger werdenden Verfahren der nichtlinearen Regelungen vor und erläutert sie. Wesentliche Merkmale des Buches sind die gute Verständlichkeit sowie die vielen Anwendungsbeispiele. Illustriert werden sie durch viele farbige Abbildungen. In dieser dritten Auflage finden sich gegenüber der zweiten Auflage erweiterte Kapitel, welche die Grundlagen der nichtlinearen Systeme komplettieren. Auch der Teil des Buches, der die regelungstechnischen Grundlagen beinhaltet, wurde in vielen Details überarbeitet. So beinhaltet die aktuelle Version all das wesentliche Wissen, das für die Lösung nichtlinearer regelungstechnischer Aufgabenstellungen erforderlich ist. Die Zielgruppen Das Buch richtet sich sowohl an fortgeschrittene Studierende der

Ingenieurwissenschaften als auch an Ingenieure in der Industrie.

Iterative Learning Control for Flexible Structures Springer

This book is about dynamical systems that are "hybrid" in the sense that they contain both continuous and discrete state variables. Recently there has been increased research interest in the study of the interaction between discrete and continuous dynamics. The present volume provides a first attempt in book form to bring together concepts and methods dealing with hybrid systems from various areas, and to look at these from a unified perspective. The authors have chosen a mode of exposition that is largely based on illustrative examples rather than on the abstract theorem-proof format because the systematic study of hybrid systems is still in its infancy. The examples are taken from many different application areas, ranging from power converters to communication protocols and from chaos to mathematical finance. Subjects covered include the following: definition of hybrid systems; description formats; existence and uniqueness of solutions; special subclasses (variable-structure systems, complementarity systems); reachability and verification; stability and stabilizability; control design methods. The book will be of interest to scientists from a wide range of disciplines including: computer science, control theory, dynamical system theory, systems modeling and simulation, and operations research.