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Control Of Nonlinear Multibody Flexible Space Structures Lecture Notes In Control And Information Sciences ***2023-09-08***

GROSS DRAKE

Control of Nonlinear Flexible Space Structures Springer
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.

Stability and Stabilization of Nonlinear Systems CRC Press

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.

Mathematical Reviews Springer

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...

Modeling, Control and Optimal Design

Springer Science & Business Media

Flexible Multibody Dynamics comprehensively describes the numerical modelling of flexible multibody dynamics systems in space and aircraft structures, vehicles, and mechanical systems. A rigorous approach is followed to handle finite rotations in 3D, with a thorough discussion of the different alternatives for parametrization. Modelling of flexible bodies is treated following the Finite Element technique, a novel aspect in multibody systems simulation. Moreover, this book provides extensive coverage of the formulation of a general purpose software for flexible multibody dynamics analysis, based on an exhaustive treatment of large rotations and finite element modelling, and incorporating useful reference material. Features include different solution techniques such as: * time integration of differential-algebraic equations * non-linear substructuring * continuation methods * nonlinear bifurcation analysis. In essence, this is an ideal text for senior undergraduates, postgraduates and professionals in mechanical and aeronautical engineering, as well as mechanical design engineers and researchers, and engineers working in areas such as kinematics and dynamics of deployable structures, vehicle dynamics and mechanical design.

Applied Mechanics Reviews Control of Nonlinear Multibody Flexible Space Structures

H... control theory is a subject that deals with the minimisation of the H... norm of the transfer matrix from an exogenous disturbance to a pertinent controlled output of a given plant. H... Control and Its Applications examines both the theoretical and practical aspects of H... control from the angle of the structural properties of linear systems. Constructive algorithms for finding solutions to general singular H... control problems are presented, as well as solutions to general H... almost disturbance decoupling problems, and the applications of the theory to real-life problems with actual implementations is also presented. The book deals with all such issues for general continuous - and discrete-time systems. The book can be used in graduate courses in departments of aeronautics and astronautics, applied mathematics, chemical engineering, electrical engineering and mechanical engineering. It is also invaluable for practising engineers in industry.

Virtual Nonlinear Multibody Systems

Springer Science & Business Media

This report summarizes the main results obtained in the ARO funded research project performed at the University of Illinois at Chicago. The objectives of this research project were to provide a comprehensive study and to develop new computational methodologies in the area of mechanics, and control of constrained deformable bodies as applied to large scale flexible mechanical systems. In this research project, a new finite element procedure, the absolute nodal coordinate formulation, was developed. This new procedure can be used for the large deformation and rotation analysis of

flexible multibody systems. It leads to exact modeling of the rigid body dynamics, and to a constant mass matrix for the finite elements in two- and three-dimensional applications. As a consequence, the vector of Coriolis and centrifugal forces is identically equal to zero. The new formulation captures the effect of the geometric centrifugal stiffness and accounts for the effect of the elastic nonlinearities. Several large deformation multibody problems were examined, and the results obtained using the new procedure were compared with the results obtained using existing finite element formulations. The results obtained in this research project are documented in several publications listed in this report.

Nonlinear Control Synthesis for Electrical Power Systems Using Controllable Series Capacitors Springer Science & Business Media

"The primary purpose of this book is to develop methods for the dynamic analysis of multibody systems (MBS) that consist of interconnected rigid and deformable components. In that sense, the objective may be considered as a generalization of methods of structural and rigid body analysis. Many mechanical and structural systems such as vehicles, space structures, robotics, mechanisms, and aircraft consist of interconnected components that undergo large translational and rotational displacements. Figure 1.1 shows examples of such systems that can be modeled as multibody systems. In general, a multibody system is defined to be a collection of subsystems called bodies, components, or substructures. The motion of the subsystems is kinematically constrained because of different types of joints, and each subsystem or component may undergo large translations and rotational displacements"--

Finite-Spectrum Assignment for Time-Delay Systems Springer

Modern Flexible Multi-Body Dynamics Modeling Methodology for Flapping Wing Vehicles presents research on the implementation of a flexible multi-body dynamic representation of a flapping wing ornithopter that considers aero-elasticity. This effort brings advances in the understanding of flapping wing flight physics and dynamics that ultimately leads to an improvement in the performance of such flight vehicles, thus reaching their high performance potential. In using this model, it is necessary to reduce body accelerations and forces of an ornithopter vehicle, as well as to improve the aerodynamic performance and enhance flight kinematics and forces which are the design optimization objectives. This book is a useful reference for postgraduates in mechanical engineering and related areas, as well as researchers in the field of multibody dynamics. Uses Lagrange equations of motion in terms of a generalized coordinate vector of the rigid and flexible bodies in order to model the flexible multi-body system Provides flight verification data and flight physics of highly flexible ornithoptic vehicles Includes an online companion site with files/codes used in application examples

A Finite Element Approach Springer Science & Business Media

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.

Scientific and Technical Aerospace Reports Springer Science & Business Media

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.

Control of Nonlinear Multibody Flexible Space Structures Cambridge University Press

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.

H∞ Control and Its Applications 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.

Theory and Applications CRC Press

Control of Nonlinear Multibody Flexible Space StructuresSpringer

Robotic Systems for Handling and Assembly Springer Science & Business Media

The presence of considerable time delays in many industrial processes is well recognized and achievable performances of conventional unity feedback control systems are degraded if a process has a relatively large time delay compared to its time constants. In this case, dead time compensation is necessary in order to enhance the performances. The most popular scheme for such compensation is the Smith Predictor, but it is unsuitable for unstable or lightly damped processes because the compensated closed-loop system always contains the process poles themselves. An alternative scheme for delay elimination from the closed-loop is the finite spectrum assignment (FSA) strategy and it can arbitrarily assign the closed-loop spectrum. One may note that the Smith Predictor Control can be found in delay systems control books and many process control books, but the FSA control is rarely included in these books. It is therefore timely and desirable to fill this gap by writing a book which gives a comprehensive treatment of the FSA approach. This is useful and worthwhile since the FSA provides not only an alternative way but also certain advantages over the Smith-Predictor. The book presents the state-of-the-art of the finite spectrum assignment for time-delay systems in frequency domain. It mainly contains those works carried out recently by the authors in this field. Most of them have been published and others are awaiting publication. They are assembled together and reorganized in such a way that the presentation is logical, smooth and systematic.

STAR Routledge

The essence of this work is the control of electromechanical systems, such as manipulators, electric machines, and power converters. The common thread that links together the results presented here is the passivity property, which is at present in numerous electrical and mechanical systems, and which has

great relevance in control engineering at this time. Amongst other topics, the authors cover: Euler-Lagrange Systems, Mechanical Systems, Generalised AC Motors, Induction Motor Control, Robots with AC Drives, and Perspectives and Open Problems. The authors have extensive experience of research and application in the field of control of electromechanical systems, which they have summarised here in this self-contained volume. While written in a strictly mathematical way, it is also elementary, and will be accessible to a wide-ranging audience, including graduate students as well as practitioners and researchers in this field.

IUTAM Symposium on Intelligent Multibody Systems – Dynamics, Control, Simulation BoD – Books on Demand

This volume encompasses prototypical, innovative and emerging examples and benchmarks of Differential-Algebraic Equations (DAEs) and their applications, such as electrical networks, chemical reactors, multibody systems, and multiphysics models, to name but a few. Each article begins with an exposition of modelling, explaining whether the model is prototypical and for which applications it is used. This is followed by a mathematical analysis, and if appropriate, a discussion of the numerical aspects including simulation. Additionally, benchmark examples are included throughout the text. Mathematicians, engineers, and other scientists, working in both academia and industry either on differential-algebraic equations and systems or on problems where the tools and insight provided by differential-algebraic equations could be useful, would find this book resourceful.

The Control Handbook Springer

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).

Theory and Experiment : Presented at the Winter Annual Meeting of the American Society of Mechanical Engineers, Anaheim, California, November 8-13, 1992 Springer

This is the biggest, most comprehensive, and most prestigious compilation of articles on control systems imaginable. Every aspect of control is expertly covered, from the mathematical foundations to applications in robot and manipulator control. Never before has

such a massive amount of authoritative, detailed, accurate, and well-organized information been available in a single volume. Absolutely everyone working in any aspect of systems and controls must have this book!

Robust Control of Nonlinear Multibody Flexible Space Structures CRC Press

The combination of fast, low-latency networks and high-performance, distributed tools for mathematical software has resulted in widespread, affordable scientific computing facilities. Practitioners working in the fields of computer communication networks, distributed computing, computational algebra and numerical analysis have been brought together to contribute to this volume and explore the emerging distributed and parallel technology in a scientific environment. This collection includes surveys and original research on both software infrastructure for parallel applications and hardware and architecture infrastructure. Among the topics covered are switch-based high-speed networks, ATM over local and wide area networks, network performance, application support, finite element methods, eigenvalue problems, invariant subspace decomposition, QR factorization and Todd-Coxseter coset enumeration.

Space Station Systems Springer

Although parallel robots are known to offer many advantages with respect to accuracy, dynamics, and stiffness, major breakthroughs in industrial applications have not yet taken place. This is due to a knowledge gap preventing fast and precise execution of industrial handling and assembly tasks. This book focuses on the design, modeling, and control of innovative parallel structures as well as the integration of novel machine elements. Special attention is paid to the integration of active components into lightweight links and passive joints. In addition, new control concepts are introduced to minimize structural vibrations. Although the optimization of robot systems itself allows a reduction of cycle times, these can be further decreased by improved path planning, robot programming, and automated assembly planning concepts described by 25 contributions within this book. The content of this volume is subdivided into four main parts dealing with Modeling and Design, System Implementation, Control and Programming as well as Adaptronics and Components. This book is aimed at researchers and postgraduates working in the field of parallel robots as well as practicing engineers dealing with industrial robot development and robotic applications.