Dynamic Simulations Of Multibody Systems

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Advanced Multibody System Dynamics Springer Science & Business Media
This volume examines the theoretical and practical needs on the subject of multibody system dynamics with emphasis on flexible systems and engineering applications. It focuses on developing an all purpose algorithm for the dynamic simulation of flexible tree-like systems making use of matrix representation at all levels. The book covers new theories with engineering applications involved in broad fields which include; civil engineering, aerospace and robotics, as well as general and mechanical engineering. The applications include high temperature conditions, time variant contact conditions, biosystem analysis, vibration minimization and control.
Flexible Multibody System Dynamics: Theory And Applications Kinematic and Dynamic Simulation of Multibody SystemsThe Real-Time Challenge
Dynamics of multibody systems is of great importance in the fields of robotics, biomechanics, spacecraft control, road and rail vehicle design, and dynamics of machinery. Many research problems have been solved and a considerable number of computer codes based on multibody formalisms is now available. With the present book it is intended to collect software systems for multibody system dynamics which are well established and have found acceptance in the users community. The Handbook will aid the reader in selecting the software system which is most appropriate to his needs. Altogether 17 research groups contributed to the Handbook. A compact summary of important capabilities of these software systems is presented in tabular form. All authors dealt with two typical test examples, a planar mechanism and a spatial robot. Thus, it is very easy to compare the results and to identify more clearly the advantages of one or the other formalism.
A Finite Element Approach to the Dynamic Simulation of Multibody Systems Morgan & Claypool Publishers
The German Research Council (DFG) decided 1987 to establish a nationwide five year research project devoted to dynamics of multibody systems. In this project universities and research centers cooperated with the goal to develop a general pur pose multibody system software package. This concept provides the opportunity to use a modular structure of the software, i.e. different multibody formalisms may be combined with different simulation programmes via standardized interfaces. For the DFG project the database RSYST was chosen using standard FORTRAN 77 and an object oriented multibody system datamodel was defined. The project included • research on the fundamentals of the method of multibody systems, • concepts for new formalisms of dynamical analysis, • development of efficient numerical algorithms and • realization of a powerful software package of multibody systems. These goals required an interdisciplinary cooperation between mathematics, compu ter science, mechanics, and control theory. ix X After a rigorous reviewing process the following research institutions participated in the project (under the responsibility of leading scientists): Technical University of Aachen (Prof. G. Sedlacek) Technical University of Darmstadt (Prof. P. Hagedorn) University of Duisburg M. Hiller) (Prof.
Transfer Matrix Method for Multibody Systems Springer Science & Business Media
Linear complementarity problems (LCPs) have for many years been used in physics-based animation to model contact forces between rigid bodies in contact. More recently, LCPs have found their way into the realm of fluid dynamics. Here, LCPs are used to model boundary conditions with fluid-wall contacts. LCPs have also started to appear in deformable models and granular simulations. There is an increasing need for numerical methods to solve the resulting LCPs with all these new applications. This book provides a numerical foundation for such methods, especially suited for use in computer graphics. This book is mainly intended for a researcher/Ph.D. student/post-doc/professor who wants to study the algorithms and do more work/research in this area. Programmers might have to invest some time brushing up on math skills, for this we refer to Appendices A and B. The reader should be familiar with linear algebra and differential calculus. We provide pseudo code for all the numerical methods, which should be comprehensible by any computer scientist with rudimentary programming skills. The reader can find an online supplementary code repository, containing Matlab implementations of many of the core methods covered in these notes, as well as a few Python implementations [Erleben, 2011].
Development and Application of Computational Dynamic and Kinematic Constrained Multi-body System Simulations in MATLAB Springer
Planar Multibody Dynamics: Formulation, Programming with MATLAB®, and Applications, Second Edition, provides sets of methodologies for analyzing the dynamics of mechanical systems, such as mechanisms and machineries, with coverage of both classical and modern principles. Using clear and concise language, the text introduces fundamental theories, computational methods, and program development for analyzing simple to complex systems. MATLAB is used throughout, with examples beginning with basic commands before introducing students to more advanced programming techniques. The simple programs developed in each chapter come together to form complete programs for different types of analysis. Features Two new chapters on free-body diagram and vector-loop concepts demonstrate that the modern computational techniques of formulating the equations of motion is

merely an organized and systematic interpretation of the classical methods A new chapter on modeling impact between rigid bodies is based on two concepts known as continuous and piecewise methods A thorough discussion on modeling friction and the associated computational issues The short MATLAB® programs that are listed in the book can be downloaded from a companion website Several other MATLAB® programs and their user manuals can be downloaded from the companion website including: a general purpose program for kinematic, inverse dynamic, and forward dynamic analysis; a semi-general-purpose program that allows student to experiment with his or her own formulation of equations of motion; a special-purpose program for kinematic and inverse dynamic analysis of four-bar mechanisms The preceding three sets of programs contain animation capabilities for easy visualization of the simulated motion A greater range of examples, problems, and projects

Multibody Dynamics Springer

Large-scale mechanical systems such as automobiles consist of interconnected rigid and deformable components. These multibody systems present complex problems. This introduction to multibody dynamics emphasises flexible body dynamics. It discusses basic kinematics and dynamics, modeling, and newer computational techniques.

Efficient Formulations and Applications Cambridge University Press

Thank heavens for Jens Wittenburg, of the University of Karlsruhe in Germany. Anyone who’s been laboring for years over equation after equation will want to give him a great big hug. It is common practice to develop equations for each system separately and to consider the labor necessary for deriving all of these as inevitable. Not so, says the author. Here, he takes it upon himself to describe in detail a formalism which substantially simplifies these tasks.

Dynamic Simulation of Multibody Systems in Simultaneous, Indeterminate Contact and Impact with Friction Springer Science & Business Media

This book will be particularly useful to those interested in multibody simulation (MBS) and the formulation for the dynamics of spatial multibody systems. The main types of coordinates that can be used in the formulation of the equations of motion of constrained multibody systems are described. The multibody system, made of interconnected bodies that undergo large displacements and rotations, is fully defined. Readers will discover how Cartesian coordinates and Euler parameters are utilized and are the supporting structure for all methodologies and dynamic analysis, developed within the multibody systems methodologies. The work also covers the constraint equations associated with the basic kinematic joints, as well as those related to the constraints between two vectors. The formulation of multibody systems adopted here uses the generalized coordinates and the Newton-Euler approach to derive the equations of motion. This formulation results in the establishment of a mixed set of differential and algebraic equations, which are solved in order to predict the dynamic behavior of multibody systems. This approach is very straightforward in terms of assembling the equations of motion and providing all joint reaction forces. The demonstrative examples and discussions of applications are particularly valuable aspects of this book, which builds the reader’s understanding of fundamental concepts.

Dynamic Simulations of Multibody Systems Springer Science & Business Media

This book introduces the techniques needed to produce realistic simulations and animations of particle and rigid body systems. It focuses on both the theoretical and practical aspects of developing and implementing physically based dynamic simulation engines that can be used to generate convincing animations of physical events involving particles and rigid bodies. It can also be used to produce accurate simulations of mechanical systems, such as a robotic parts feeder. The book is intended for researchers in computer graphics, computer animation, computer-aided mechanical design and modeling software developers.

A Finite Element Approach Springer Science & Business Media

Modeling of the global motion of mechanical systems superimposed by large flexible deflections and small deformations are subjects that require special consideration. One of the main problems in the dynamics simulation of moving systems it is the precision of the dynamics equations. Novel generalized Newton - Euler dynamic equations for rigid and flexible bodies are proposed. Unified approach to simulation of rigid and flexible systems is developed. The dynamic equations are expressed with respect to the quasi - velocities and accelerations as for the flexible nodes so for the rigid bodies. The method is independent of the selection of the motion coordinates. The equations are compatible with every program system for Finite Element analysis and applicable as for absolute nodal coordinate formulation so for FE in relative coordinates. The novel methodology and approach to dynamics modeling of rigid and flexible systems considerably improves the precision of the simulation process and the reality of a virtual prototype. The book is devoted to scientists and engineers, as well as, to software developers dealing with the problems of mechanical system simulation, analysis and design.

Modeling, Control and Optimal Design Springer Science & Business Media

Modeling and analysing multibody systems require a comprehensive understanding of the kinematics and dynamics of rigid bodies. In this volume, the relevant fundamental principles are first reviewed in detail and illustrated in conformity with the multibody formalisms that follow. Whatever the kind of system (tree-like structures, closed-loop mechanisms, systems containing flexible beams or involving tire/ground contact, wheel/rail contact, etc), these multibody formalisms have a common feature in the proposed approach, viz, the symbolic generation of most of the ingredients needed to set up the model. The symbolic approach chosen, specially dedicated to multibody systems, affords various advantages: it leads to a simplification of the theoretical formulation of models, a considerable reduction in the size of generated equations and hence in resulting computing time, and also enhanced portability of the multibody models towards other specific environments. Moreover, the generation of multibody models as symbolic toolboxes proves to be an excellent pedagogical medium in teaching mechanics.

Theory and Applications John Wiley & Sons

This research is focused on improving the solutions obtained using theory in contact and impact modeling. A theoretical framework is developed which can simulate the performance of dynamic systems within a real world environment. This environment involves conditions, such as contact, impact and friction. Numerical simulation provides an easy way to perform numerous iterations with varying conditions, which is more cost effective than building equivalent experimental setups. The developed framework will serve as a tool for engineers and scientists to gain some insight on predicting how a system may behave. The current field of research in multibody system dynamics lacks a framework for modeling simultaneous, indeterminate contact and impact with friction. This special class of contact and impact problems is the major focus of this research. This research develops a framework, which contributes to the existing literature. The contact and impact problems examined in this work are indeterminate with respect to the impact forces. This is problematic because the impact forces are needed to determine the slip-state of contact and impact points. The novelty of the developed approach relies on the formation of constraints among the velocities of the impact points. These constraints are used to address the indeterminate nature of the collisions encountered. This approach strictly adheres to the assumptions of rigid body modeling in conjunction with the notion that the configuration of the system does not change in the short time span of the collision. These assumptions imply that the impact Jacobian is constant during the collision, which enforces a kinematic relationship between the impact points. The developed framework is used to address simultaneous, indeterminate contact and impact problems with friction. In the preliminary stages of this research, an iterative method, which incorporated an optimization function was used obtain the solutions for numerical solution to the collision. In an effort to improve the time and accuracy of the results, the iterative method was replaced with an analytical approach and implemented with the constraint formulation to achieve more energetically consistent solutions (i.e. there are no unusual gains in energy after the impact). The details of why this claim is valid will be discussed in more detail in this dissertation. The analytical framework was developed for planar contact and impact problems, while a numerical framework is developed for three-dimensional (3D) problems. The modeling of friction in 3D presents some challenging issues that are well documented in the literature, which make it difficult to apply an analytical framework. Simulations are conducted for a planar ball, planar rocking block problem, Newton's Cradle, 3D sphere, and 3D rocking block. Some examples serve as benchmark problems, in which the results are validated using experimental data.

Numerical Multibody System Dynamics John Wiley & Sons

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.

Multibody Dynamics with Unilateral Contacts Routledge

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.

Robot and Multibody Dynamics John Wiley & Sons Incorporated

The main objective of this research is the development of a framework for the automatic generation of systems of kinematic and dynamic equations that are suitable for real-time applications. In particular, the efficient simulation of constrained multibody systems is addressed. When modelled with ideal joints, many mechanical systems of practical interest contain closed kinematic chains, or kinematic loops, and are most conveniently modelled using a set of generalized coordinates of cardinality exceeding the degrees-of-freedom of the system. Dependent generalized coordinates add nonlinear algebraic constraint equations to the ordinary differential equations of motion, thereby producing a set of differential-algebraic equations that may be difficult to solve in an efficient yet precise manner.

System Dynamics Elsevier

Multibody systems are the appropriate models for predicting and evaluating performance of a variety of dynamical systems such as spacecraft, vehicles, mechanisms, robots or biomechanical systems. This book adresses the general problem of analysing the behaviour of such multibody systems by digital simulation. This implies that pre-computer analytical methods for deriving the system equations must be replaced by systematic computer oriented formalisms, which can be translated conveniently into efficient computer codes for - generating the system equations based on simple user data describing the system model - solving those complex equations yielding results ready for design evaluation. Emphasis is on computer based derivation of the system equations thus freeing the user from the time consuming and error-prone task of developing equations of motion for various problems again and again.

Proceedings of the 9th ECCOMAS Thematic Conference on Multibody Dynamics Springer Science & Business Media

As mechanical systems become more complex so do the mathematical models and simulations used to describe the interactions of their parts. One area of multibody theory that has received a great deal of attention in recent years is the dynamics of multiple contact situations occurring in continuous joints and couplings. Despite the rapid gains in our understanding of what occurs when continuous joints and couplings interact, until now there were no books devoted exclusively to this intriguing phenomenon. Focusing on the concerns of practicing engineers, Multibody Dynamics with Unilateral Contacts presents all theoretical and applied aspects of this subject relevant to a practical understanding of multiple unilateral contact situations in multibody mechanical systems. In Part 1, Professor Pfeiffer and Dr. Glocker provide an exhaustive review of the laws and principles governing the dynamics of unilateral contacts in multibody mechanical and technical systems. Among the topics covered are multibody and contact kinematics, the dynamics of rigid body systems, multiple contact configurations, detachment and stick-slip transitions, frictionless impacts, impacts with friction, and the Corner law of contact dynamics. In Part 2, the authors present numerous applications of the theories presented in Part 1. Each chapter in this part is devoted to a different law, theory, or model, such as discontinuous force laws, classical impact theory, Coulomb's friction law, and mechanical and mathematical models of impacts and friction. In addition, each chapter features several practical examples that allow engineers to observe the concepts described in action. Examples are drawn from a broad array of fields and range from hammering in gears as occurring in a synchronous generator to impacts and friction as observed in a child's woodpecker toy, from a demonstration of classical impact theory using an automobile gear box example, to Coulomb's friction law as applied to a turbine blade damper. Multibody Dynamics with Unilateral Contacts is an indispensable resource for mechanical engineers working on all types of multibody systems and the friction and vibration problems that can occur in them. It is also a valuable reference for researchers studying nonlinear dynamics. The only book devoted entirely to the theory and applications of onE of the most crucial aspects of multibody system design. This is the first book to focus exclusively on the theory and applications of multiple contact situations occurring in continuous joints and couplings in multibody systems. As such, it is a valuable resource for engineers working on mechanical systems with interrelated multiple parts. Multibody Dynamics with Unilateral Contacts * Provides a comprehensive examination of the laws and principles governing the dynamics of unilateral contacts in multibody mechanical and technical systems. * Presents the latest mathematical models and simulation techniques for describing the interactions of joints and couplings in multibody systems. * Describes practical applications for all the concepts covered. * Includes numerous examples drawn from a wide range of fascinating and enlightening real-world demonstrations, including everything from an airplane's landing gear to a child's toy.

Dynamics of Underactuated Multibody Systems Routledge

Multibody Systems Approach to Vehicle Dynamics aims to bridge a gap between the subject of classical vehicle dynamics and the general-purpose computer-based discipline known as multibody systems analysis (MBS). The book begins by describing the emergence of MBS and providing an overview of its role in vehicle design and development. This is followed by separate chapters on the modeling, analysis, and post-processing capabilities of a typical simulation software; the modeling and analysis of the suspension system; tire force and moment generating characteristics and subsequent modeling of these in an MBS simulation; and the modeling and assembly of the rest of the vehicle, including the anti-roll bars and steering systems. The final two chapters deal with the simulation output and interpretation of results, and a review of the use of active systems to modify the dynamics in modern passenger cars. This book intended for a wide audience including not only undergraduate, postgraduate and research students working in this area, but also practicing engineers in industry who require a reference text dealing with the major relevant areas within the discipline. * Full of practical examples and applications * Uses industry standard ADAMS software based applications * Accompanied by downloadable ADAMS models and data sets available from the companion website that enable readers to explore the material in the book * Guides readers from modelling suspension movement through to full vehicle models able to perform handling manoeuvres

Dynamics and Balancing of Multibody Systems Academic Press

Robot and Multibody Dynamics: Analysis and Algorithms provides a comprehensive and detailed exposition of a new mathematical approach, referred to as the Spatial Operator Algebra (SOA), for studying the dynamics of articulated multibody systems. The approach is useful in a wide range of applications including robotics, aerospace systems, articulated mechanisms, bio-mechanics and molecular dynamics simulation. The book also: treats algorithms for simulation, including an analysis of complexity of the algorithms, describes one universal, robust, and analytically sound approach to formulating the equations that govern the motion of complex multi-body systems, covers a range of more advanced topics including under-actuated systems, flexible systems, linearization, diagonalized dynamics and space manipulators. Robot and Multibody Dynamics: Analysis and Algorithms will be a valuable resource for researchers and engineers looking for new mathematical approaches to finding engineering solutions in robotics and dynamics.

Dynamics and Simulation of Flexible Rockets Elsevier

Filling the gaps between subjective vehicle assessment, classical vehicle dynamics and computer-based multibody approaches, The Multibody Systems Approach to Vehicle Dynamics offers unique coverage of both the virtual and practical aspects of vehicle dynamics from concept design to system analysis and handling development. The book provides valuable foundation knowledge of vehicle dynamics as well as drawing on laboratory studies, test-track work, and finished vehicle applications to gel theory with practical examples and observations. Combined with insights into the capabilities and limitations of multibody simulation, this comprehensive mix provides the background understanding, practical reality and simulation know-how needed to make and interpret useful models. New to this edition you will find coverage of the latest tire models, changes to the modeling of light commercial vehicles, developments in active safety systems, torque vectoring, and examples in AView, as well as updates to theory, simulation, and modeling techniques throughout. Unique gelling of foundational theory, research findings, practical insights, and multibody systems modeling know-how, reflecting the mixed academic and industrial experience of this expert author team Coverage of the latest models, safety developments, simulation methods, and features bring the new edition up to date with advances in this critical and evolving field