Multi Body Simulation And Multi Objective Optimization

Gives readers a more thorough understanding of DEM and equips researchers for independent work and an ability to judge methods related to simulation of polygonal particles Introduces DEM from the fundamental concepts (theoretical mechanics and solidstate physics), with 2D and 3D simulation methods for polygonal particles Provides the fundamentals of coding discrete element method (DEM) requiring little advance knowledge of granular matter or numerical simulation Highlights the numerical tricks and pitfalls that are usually only realized after years of experience, with relevant simple experiments as applications Presents a logical approach starting withthe mechanical and physical bases,followed by a description of the techniques and finally their applications Written by a key author presenting ideas on how to model the dynamics of angular particles using polygons and polyhedral Accompanying website includes MATLAB-Programs providing the simulation code for two-dimensional polygons Recommended for researchers and graduate students who deal with particle models in areas such as fluid dynamics, multi-body engineering, finite-element methods, the geosciences, and multi-scale physics.

"This enhanced fourth edition of Dynamics of Multibody Systems includes an additional chapter that provides explanations of some of the fundamental issues addressed in the book, as well as new detailed derivations of some important problems. Many common mechanisms such as automobiles, space structures, robots, and micromachines have mechanical and structural systems that consist of interconnected rigid and deformable components. The dynamics of these large-scale multibody systems are highly nonlinear, presenting complex problems that in most cases can only be solved with computer-based techniques. The book begins with a review of the basic ideas of kinematics and the dynamics of rigid and deformable bodies before moving on to more advanced topics and computer implementation. The book's wealth of examples and practical applications will be useful to graduate students, researchers, and practising engineers working on a wide variety of flexible multibody systems"--

Mobility of wheeled vehicles on deformable ground concerns a wide variety of industries, including: agriculture, forestry, mining, recreation, and military. Commercial software is available to model and simulate entire vehicle systems but lacks the ability to accurately simulate mobility on soft soil for most driving maneuvers. This thesis focuses on building a framework to extend vehicle dynamics mobility simulation on deformable terrain to allow for general driving maneuvers. First, a deformable terrain model with a stress/strain relationship informed from soil mechanics is discussed and described in the context of a three-dimensional description of the terrain surface. The second major effort is to quantify the tire/terrain contact patch, both in shape, size and the normal and shear stress distributions, which is used as the boundary condition at the surface of the terrain model. Computational bottlenecks are identified and parallel CPU and Graphics Processor Unit hardware is leveraged using OpenMP and CUDA, respectively, resulting in an order of magnitude speed-up. The new tire/terrain model is validated at two different levels: static load/deflection tests used in the deformable tire model parameter identification, and a tire testing rig in a multibody dynamics simulation engine. In-plane steady-state wheel performance is analyzed: drawbar pull, motion resistance, thrust, torque and the normal and shear stress along the centerline of the contact patch. These tests are run over a range of wheel sizes, weights, inflation pressure and slip rates on firm and loose clay loam soil. Validation is carried out using both experimental data found in the literature, as well as two-dimensional equilibrium semi-empirical methods. It is shown that the newly developed model predicts higher drawbar pull than the two-dimensional methods, but less than the experimentally reported values due to the lack of lugs in the current model. Contact stress distributions are shown to agree well with the semi-empirical methods along the tire centerline, and has a three-dimensional contact profile which agrees well with the experimental results. A dynamically driven wheel is shown to have different contact stress distributions at different wheel velocities, independent of slip, illustrating the need to consider these variables separately.

Multi-body dynamics is an important and little published field of mechanical engineering. Contained in this volume are the refereed papers from the First International Symposium on Multi-Body Dynamics: Monitoring and Simulation Techniques. In presenting their valuable experiences, leading researchers from all aspects of multi-body dynamics highlight and integrate the range of techniques employed in dealing with complex dynamic problems encountered in various industries. The papers, from leading academic researchers and professional engineers, cover applications in automotive, aerospace, machine tool, turbo-machinery, and other sectors of industry.

This text deals with the simulation of the tyre/suspension dynamics by using recurrent dynamic neural networks. Recurrent neural networks are based on the multilayer feedforward neural networks, by adding feedback connections between output and input layers. The neural network can be trained with data obtained from the simulation of a physical model created using a multi-body simulation software (SIMPACK). The results obtained from the neural network demonstrate a good agreement that could be improved, depending on some factors, with the multi-body model simulation results. The neural network model can be applied as a part of vehicle system model to predict system dynamic behaviour. Although the neural network model does not provide a good insight of the physical behaviour of the system, it is a useful tool to help in vehicle ride dynamics performance due to its good efficiency and accuracy in computational terms.

This document presents the results of computer-based, vehicle dynamics performance assessments of Future Truck concepts with such features as a vanable height, hydraulic, trailing arm suspension, skid steering, and in-hub electric drive motors. Fully three-dimensional Future Truck models were created using a commercially available modeling and simulation methodology and limited validation studies were performed by comparing model predictions with baseline, validated model predictions from another vehicle in the same size and class as the Future Truck concept vehicles. The models were considered accurate enough to predict various aspects of ride quality and stability performance, critical to US Army Objective Force mission needs. One-to-one comparisons of the Future Truck concepts and a standard, solid-axle, Heavy Tactical Vehicle (HTV) operating in various terrain and obstacle negotiation conditions were performed.

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.

Mechanical engineering, an engineering discipline born of the needs of the industrial revolution, is once again asked to do its substantial share in the call for industrial renewal. The general call is urgent as we face profound issues of productivity and competitiveness that require engineering solu tions, among others. The Mechanical Engineering Series features graduate texts and research monographs intended to address the need for informa tion in contemporary areas of mechanical engineering. The series is conceived as a comprehensive one that will cover a broad range of concentrations important to mechanical engineering graduate edu cation and research. We are fortunate to have a distinguished roster of consulting editors, each an expert in one of the areas of concentration. The names of the consulting editors are listed on the front page of the volume. The areas of concentration are applied mechanics, biomechanics, computa tional mechanics, dynamic systems and control, energetics, mechanics of material, processing, thermal science, and tribology. Professor Leckie, the consulting editor for applied mechanics, and I are pleased to present this volume of the series: Kinematic and Dynamic Simulation of Multibody Systems: The Real-Time Challenge by Professors Garcia de Jal6n and Bayo. The selection of this volume underscores again the interest of the Mechanical Engineering Series to provide our readers with topical monographs as well as graduate texts. Austin Texas Frederick F. Ling v The first author dedicates this book to the memory of Prof F. Tegerizo (t 1988), who introduced him to kinematics.

Underactuated multibody systems are intriguing mechatronic systems, as they posses fewer control inputs than degrees of freedom. Some examples are modern light-weight flexible robots and articulated manipulators with passive joints. This book investigates such underactuated multibody systems from an integrated perspective. This includes all major steps from the modeling of rigid and flexible multibody systems, through nonlinear control theory, to optimal system design. The underlying theories and techniques from these different fields are presented using a self-contained and unified approach and notation system. Subsequently, the book focuses on applications to large multibody systems with multiple degrees of freedom, which require a combination of symbolical and numerical procedures. Finally, an integrated, optimization-based design procedure is proposed, whereby both structural and control design are considered concurrently. Each chapter is supplemented by illustrated examples.

Dynamics and Simulation of Flexible Rockets provides a full state, multiaxis treatment of launch vehicle flight mechanics and provides the state equations in a format that can be readily coded into a simulation environment. Various forms of the mass matrix for the vehicle dynamics are presented. The book also discusses important forms of coupling, such as between the nozzle motions and the flexible body. This book is designed to help practicing aerospace engineers create simulations that can accurately verify that a space launch vehicle will successfully perform its mission. Much of the open literature on rocket dynamics is based on analysis techniques developed during the Apollo program of the 1960s. Since that time, large-scale computational analysis techniques and improved methods for generating Finite Element Models (FEMs) have been developed. The art of the problem is to combine the FEM with dynamic models of separate elements such as sloshing fuel and moveable engine nozzles. The pitfalls that may occur when making this marriage are examined in detail. Covers everything the dynamics and control engineer needs to analyze or improve the design of flexible launch vehicles Provides derivations using Lagrange's equation and Newton/Euler approaches, allowing the reader to assess the importance of nonlinear terms Details the development of linear models and introduces frequency-domain stability analysis techniques Presents practical methods for transitioning between finite element models, incorporating actuator dynamics, and developing a preliminary flight control design

Multi-body dynamics describes the physics of motion of an assembly of constrained or restrained bodies. As such it encompasses the behaviour of nearly every living or inanimate object in the universe. Multi-body dynamics - Monitoring and Simulation Techniques III includes papers from leading academic researchers, professional code developers, and practising engineers, covering recent fundamental advances in the field, as well as applications to a host of problems in industry.They broadly cover the areas: Multi-body methodology Structural dynamics Engine dynamics Vehicle dynamics - ride and handling Machines and mechanisms Multi-body Dynamics is a unique volume, describing the latest developments in the field, supplemented by the latest enhancements in computer simulations, and experimental measurement techniques. Leading industrialists explain the importance attached to these developments in industrial problem solving.

The 13th International Conference on Human–Computer Interaction, HCI Inter- tional 2009, was held in San Diego, California, USA, July 19–24, 2009, jointly with the Symposium on Human Interface (Japan) 2009, the 8th International Conference on Engineering Psychology and Cognitive Ergonomics, the 5th International Conference on Universal Access in Human–Computer Interaction, the Third International Conf- ence on Virtual and Mixed Reality, the Third International Conference on Internati- alization, Design and Global Development, the Third International Conference on Online Communities and Social Computing, the 5th International Conference on Augmented Cognition, the Second International Conference on Digital Human Mod- ing, and the First International Conference on Human Centered Design. A total of 4,348 individuals from academia, research institutes, industry and gove- mental agencies from 73 countries submitted contributions, and 1,397 papers that were judged to be of high scientific quality were included in the program. These papers - dress the latest research and development efforts and highlight the human aspects of the design and use of computing systems. The papers accepted for presentation thoroughly cover the entire field of human–computer interaction, addressing major advances in knowledge and effective use of computers in a variety of application areas.

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.

Fundamentals of Multibody DynamicsTheory and ApplicationsSpringer 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.

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.

The United States Army Research, Development, and Engineering Command's Tank Automotive Research, Development and Engineering Center (U.S. Army RDECOM-TARDEC) laboratories is seeking to advance modeling and simulation methods used for predicting the performance of ground vehicles. TARDEC typically generates non-real-time models of its vehicles using DADS: a general purpose commercial, multi-body software package based on a Cartesian coordinate formulation. TARDEC also currently uses SimCreator to develop real-time multi-body vehicle models. SimCreator uses recursive techniques to perform the simulations in real-time. The goal of the study presented here was to develop rapid conversion methods for translating models of DADS and other commercial multibody software packages into SimCreator models. A procedure that can be automated was developed to convert a DADS model of a High-Mobility Multipurpose Wheeled Vehicle (HMMVW) to a SimCreator model. The vehicle model consisted of the chassis base body and the 4 wheels connected to it with double A-Arm suspensions and steering constraints. This model with 2 closed kinematic loops at each suspension was preprocessed to determine the best joints to be used as constraints (cut joints). The Cartesian joint coordinates of the DADS models were converted to relative joint coordinates used by SimCreator. Bodies, joints, and force elements were then converted using the components from SimCreator's multi-body dynamics library. In place of the radial spring tire model used in the DADS simulation, a multi-disc tire model was developed to be used with SimCreator.

The authors examine in detail the fundamentals and mathematical descriptions of the dynamics of automobiles. In this context, different levels of complexity are presented, starting with basic single-track models up to complex three-dimensional multi-body models. A particular focus is on the process of establishing mathematical models based on real cars and the validation of simulation results. The methods presented are explained in detail by means of selected application scenarios. In addition to some corrections, further application examples for standard driving maneuvers have been added for the present second edition. To take account of the increased use of driving simulators, both in research, and in industrial applications, a new section on the conception, implementation and application of driving simulators has been added.

Historically machine and mechanism design relied heavily upon analytical and graphical means to evaluate the performance a system. With increasing complexity, these methods have been modified for use with computational tools. General purpose solvers have been created such as Adams, DADS and Dap3d to analyze different machines and mechanisms. Although these tools are available, they allow limited access to source code or utilize a language that is not readily taught in academics. This thesis will focus on the creation of a general-purpose simulation enviroment using the currently used programming language Matlab. Four simulation programs have been created allowing simulation of kinematics and dynamics for planar and spatial mechanical systems. Discussed along with the program operation is the mathematics behind normal computational dynamics. A section is dedicated to the solution and its implementation of purely kinematic methods allowing the solution of planar and spatial systems. Constraints are heavily utilized in the formation of multi-body systems and their equations and formulations are detailed. For spatial kinematic simulations, Euler parameters are discussed in detail, and the related equations needed for multibody system simulations have been provided. The mathematics of the dynamic simulations is also discussed, along with addition of non-rigid elements such as springs and dampers. Example simulations of specific systems have also been included, showing the results of interest utilizing the graphical user interfaces that have been created. Along with these examples is a simulation that includes two dimensional beam elements injected into the dynamic solver, which illustrates how multiple fields of engineering can be included in the simulations

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.

This textbook – a result of the author's many years of research and teaching – brings together diverse concepts of the versatile tool of multibody dynamics, combining the efforts of many researchers in the field of mechanics.

The mechanics of contact between rough and imperfectly spherical adhesive powder grains are often complicated by a variety of factors, including several which vary over sub-grain length scales. These include several traction factors that vary spatially over the surface of the individual grains, including high energy electron and acceptor sites (electrostatic), hydrophobic and hydrophilic sites (electrostatic and capillary), surface energy (general adhesion), geometry (van der Waals and mechanical), and elasto-plastic deformation (mechanical). For mechanical deformation and reaction, coupled motions, such as twisting with bending and sliding, as well as surface roughness add an asymmetry to the contact force which invalidates assumptions for popular models of contact, such as the Hertzian and its derivatives, for the non-adhesive case, and the JKR and DMT models for adhesive contacts. Though several contact laws have been offered to ameliorate these drawbacks, they are often constrained to particular loading paths (most often normal loading) and are relatively complicated for computational implementation. This paper offers a simple and general computational method for augmenting contact law predictions in multi-body simulations through characterization of the contact surfaces using a hierarchically-defined surface sub-discretization. For the case of adhesive contact between powder grains in low stress regimes, this technique can allow a variety of existing contact laws to be resolved across scales, allowing for moments and torques about the contact area as well as normal and tangential tractions to be resolved. This is especially useful for multi-body simulation applications where the modeler desires statistical distributions and calibration for parameters in contact laws commonly used for resolving near-surface contact mechanics. The approach is verified against analytical results for the case of rough, elastic spheres.

Modeling and computer simulation play an important role in all engineering disciplines. As specialized simulation tools have become very sophisticated and, at the same time, the simulation of complex systems and phenomena showed the limits of mono-disciplinary approaches, multi-disciplinary simulation has gained wide acceptance. For the coupling of different simulation tools interfaces are necessary, including both aspects of physics and numerics as well as of software engineering. This paper tries to give a general classification of interfaces between simulation tools. Following, the multibody simulation approach is presented. With a great number of interfaces to other engineering disciplines like FEA, CAD, CFD, and control design engineering, multibody simulation programs are true multidisciplinary tools which can be used from the pre-design phase to trouble shooting on a production vehicle. As an example, the MBS tool SIMPACK and its integration in the concurrent engineering loop will be presented along with two applications from automotive and aerospace design.

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

This book is intended to familiarize you with the basics of theory and practice in Adams Multibody Dynamics (MBD) modeling. The content has been developed to be beneficial to readers who are students or practicing engineers who are either completely new to MBD modeling or have some experience with MBD modeling. The author's lengthy experience using the Adams software adds a practical and, occasionally, humorous complement to standard documentation and training materials, intended to benefit you while learning Adams. The book features relatively small examples which you can readily build and execute. This book contains an introduction to Adams theory which provides the basics on how Adams models are formulated and then numerically solved. Finally, this book concludes with some success stories taken from industry.

Anyone who wants to simulate the behavior of vehicles must think about how they want to model the vehicle's chassis. Depending on the question (vehicle dynamics, ride comfort, load data prediction ...) there are a variety of possibilities. This book should help to find and implement the right models and processes. In addition to a short introduction to simulation technology, the most important types of modelling for the assemblies of the chassis using the method of multi-body systems are presented. However, successful simulation does not only mean the assembly of suitable models, but always represents a well thought-out process that goes from data acquisition to the validation of the models. This will be discussed using suitable examples for concrete questions.

The important interaction between modeling and solution techniques is demonstrated by using a simplified multibody model of a truck thoughout the book to illustrate all key concepts.