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General information

The coupling of models from different physical domains and the efficient and reliable simulation of multidisciplinary problems in engineering applications are important topics for various fields of engineering, in simulation technology and in the development and analysis of numerical solvers.

The volume presents advanced modelling and simulation techniques for the dynamical analysis of coupled engineering systems consisting of mechanical, electrical, hydraulic and biological components as well as control devices often based on computer hardware and software. The book starts with some basics in multibody dynamics and in port-based modelling and focuses on the modelling and simulation of heterogeneous systems with special emphasis on robust and efficient numerical solution techniques and on a variety of applied problems including case studies of co-simulation in industrial applications, methods and problems of model based controller design and real-time applications.

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PREFACE

In general, dynamical systems consist of mechanical, electrical, hydraulic and biological components as well as control devices often based on computer hardware and software. The design of such systems requires advanced modelling and simulation techniques that are tailored to multidisciplinary problems. The coupling of models from different physical domains and the efficient and reliable simulation of coupled physical phenomena in engineering applications are topics of active research in various fields of engineering, in simulation technology and in the development and analysis of numerical solvers.

The methods and software tools of multibody dynamics illustrate the large potential of advanced monodisciplinary simulation techniques in the integrated design of heterogeneous engineering systems. Non-mechanical system components are either considered by appropriate extensions of classical multibody system simulation tools or by the coupling with standard tools from other disciplines like hydraulics or computer aided control engineering in a co-simulation framework. Alternatively, the heterogeneous engineering system may be described in a unified modelling framework for multidisciplinary applications. Bond graph modelling or, more general, port-based modelling techniques as well as general modelling languages like VHDL-AMS and Modelica are typical representatives of this unified approach.

The Advanced School “Simulation Techniques for Applied Dynamics” was held at CISM, International Centre for Mechanical Sciences, Udine (Italy), from the 17th to the 21st of September, 2007. The Course was addressed to engineers, mathematicians and physicists from industry and research institutes, who are concerned with system dynamics, control and computer simulation of mechanical and mechatronic systems, and to research scientists and students with interests in the theoretical background and in practical applications of computer simulation in applied dynamics.

The lecturers aimed at providing detailed knowledge on modelling and simulation of mechatronic systems with applications to dynamical analysis and model based controller design. It is a pleasure to see that all seven lecturers have contributed to this proceedings volume.

The book starts with some basics in the classical theory of rigid multibody systems and a typical extension to biomechanic system simulation (W. Schiehlen and P. Eberhard).

The dynamic analysis of flexible multibody systems results in challenging problems for modelling, simulation and control that are discussed in the contribution of O. Brüls et al. The methods are applied to simulation and control of a vehicle with semi-active suspension and to the motion and vibration control of a large flexible manipulator.

Modelling, simulation and control of mechatronic systems are studied in great detail by M. Valášek who starts with a general introduction to mechatronic systems and considers methods for model setup, simulation and control that are applied in suspension and engine studies illustrating the benefits of model predictive control strategies.

Port-based techniques for the unified modelling of multidomain physical systems in engineering applications are introduced in the contribution of P. Breedveld. The underlying bond graph notation is domain independent and combines physical and computational structure which contributes to a substantial speed-up of the modelling process.

The efficient and reliable simulation of complex engineering systems is a demanding task for numerical solution methods. The extension of highly developed numerical solvers from multibody dynamics to multidisciplinary coupled problems is discussed in the chapter on numerical methods for simulation in applied dynamics (M. Arnold).

Hardware- and human-in-the-loop applications require dynamical simulations in real time. J. Cuadrado et al. investigate a real-time capable combination of optimized multibody formalisms with appropriate time integration methods. Their approach is validated by experiments with a prototype car and may be used as well for controller design through human-in-the-loop simulations.

In a final contribution, P. Eberhard et al. present advanced applications of the methods of multibody dynamics in technical design processes. A flatness-based control concept and multicriteria optimization techniques are applied to highly nonlinear parallel kinematic machines. The dynamics of gearwheels is analysed taking into account the details of impact-like contacts in geartrains for Diesel engines.

It was the common goal of all authors to provide a comprehensive introduction to state-of-the-art and recent developments in the dynamical simulation and control of heterogeneous systems.

Martin Arnold and Werner Schiehlen