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Zastosowanie Metody Elementów Skończonych Czasu Rzeczywistego w symulacji hybrydowej

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Summary

The following thesis concerns methods for model order reduction that apply to hybrid simulation. Hybrid simulation is a method for investigating mechanical systems containing parts that are hard or impossible to model numerically. The method involves simultaneous numerical analysis and experiment. The investigated mechanical system is divided into a physical subsystem (physical parts connected to actuators and tested experimentally) and virtual subsystem (numerically modeled using Finite Element Method - FEM). In the experiment, the physical subsystem is deformed exactly as it would be deformed as a part of the whole mechanical system under a given load. When the dynamics of the system are taken into account, the FEM computations must be performed in real time in order to control the motion of the actuators in a closed loop.

The presented work proved that the finite element model order reduction allows to perform real-time computations, using a microcontroller, for hybrid simulation of mechanical systems with greater number of degrees of freedom (without increasing the time step), and obtaining correct results. Methods for model order reduction were developed taking into account the substructuring of the model. These methods utilize mode superposition, dynamic condensation and metamodeling techniques.

In addition, an algorithm for using field-programmable gate arrays (FPGAs) to support real-time FEM computations is presented. The algorithm consists in solving the system of equations in the FPGA by a direct method in every time step.