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Detailed Multibody Simulation in Real Time

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ABSTRACT — Multibody dynamics provides an open, fast and detailed approach to mechanical system simulation. Although fast, the speed of simulation does not generally solve in *real time*, meaning the system simulation does not update information at the same rate as it receives data. For automotive systems, the rate demands usually require 1000 Hz or more, or in other words, results within 1 millisecond time steps.

Real time simulations of mechanical systems are becoming more and more important in the autonomous vehicle market, where a vehicle is capable of guiding itself through sensing and navigating its environment without human intervention. Real time response of the vehicle dynamics is an important consideration in maintaining safety of autonomous detection and avoidance systems. Industry estimates over one million of driving hours would be required to certify the safety of new autonomous vehicle systems through various scenarios. This is physically not possible to do when automotive OEMs have business objectives to deliver an autonomous product within two years, so they are looking for a virtual solution to meet market demands.

Previous to this work, details of a multibody system are removed or reduced so that the system can be solved in real time. Most of the modeling parameters of the mechanical system are lost in this process. The mechanical model becomes a black box, making it impossible to perform what if, parameter or optimization studies of the whole system in real time.

This paper will focus on the strategy and advances in a multibody system software that enable it to solve detailed mechanical systems in real time. Advances in hardware, OS and software solution algorithms are making it possible. The 'variable amount of computational work per time step' of conventional variable step integrators make them obsolete for the real-time simulations especially when a real-time operating system (RTOS) is used. A real time integrator (a.k.a fixed step integrator) is introduced to this end. This Integrator ensures that both the multibody simulation speed and the communication interval meet the real time platform/hardware requirements (e.g. driving simulator, or abs controller). A fixed step option is introduced for the GSTIFF integrator supporting both the I3 and SI2 formulations and for the HHT integrator. The purpose of the fixed step option is to ensure that a fixed amount of work is completed in a given time interval to satisfy the requirements of RTOS. This is achieved by limiting the number of Newton steps in the implicit solve, i.e., number of iterations per solver integration step. Moreover, this integrator significantly reduces integrator-specific computational overheads of a conventional variable step integrator.

The Functional Mockup Interface, an open standard for system and tools integration is being leveraged to integrate virtual systems in SIMulation Workbench (SimWB) running on RedHawk Linux, a RTOS from Concurrent. SimWB is a convenient framework for integrating the multibody system with hardware or other software, and solving the combined system in real time.

Results of a full vehicle modeled and solved using Adams will be presented. These results will show the possibility of solving detailed multibody dynamics models in real time, making it possible to conduct virtual prototyping of autonomous vehicle systems.