Modeling and Numerical Considerations for the Real-Time Simulation of Mechanical Systems

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The first goal of this presentation is to discuss a fully Cartesian formulation that supports simple and fast generation of model specific quantities required for the dynamic analysis of a mechanical system. These quantities include generalized forces, constraint equations, and most importantly appropriate derivative information. In the considered formulation, the index three constrained equations of motion of a mechanical system are expressed in terms of global translational and angular velocities. The orientation of each body in the system is described by means of Euler parameters. A second goal of the presentation is to introduce and analyze a state-space based algorithm that leverages mechanical system information, such as the topology of the mechanism for fast linear algebra. Parallel sparse iterative algorithms are considered for computing the acceleration, Lagrange multiplier, velocity, and position model specific unknowns. The topology of the mechanical system is showed to play an important role in the numerical solution as it induces parallel computational threads that start in the equation formulation and continue through the numerical algorithms. A task scheduling procedure synchronizes these parallel threads to redeem real-time performance for certain classes of applications.