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A TIME-STEPPING SCHEME TO MODEL INELASTIC COLLISIONS IN MULTI-RIGID-BODY SYSTEMS

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ABSTRACT

Modelling of unilateral constraints in a system of interconnected bodies is a frequently encountered problem in design and optimization of mechanisms, robotic manipulators, automobiles, manufacturing assemblies and complex spacecrafts.

Traditionally, there are two different strategies to model intermittent contact. The first approach is to model the local deformation on interacting bodies with the associated contact forces being determined from the contact model. Such treatments capture the local dynamic behaviour in and around the contact site which often exists at sufficiently small spatial and temporal time scales relative to that of the primary motion of the system as to be of no interest.

The second approach is to focus on the kinematic constraints and impulsive changes in the state ignoring the local deformation at the contacts. The contact process is governed by a set of complementarity rules also known as Signorinis law. In the classical approach, a multibody system with m_B bilateral constraints and m_U unilateral constraints results in an expensive $O(2^{m_U})$ combinatorial problem of determining a consistent set of contact states. The use of complementarity methods significantly alleviates this $O(2^{m_U})$ combinatorial process by extending the contact laws to unambiguously describe transitions for all possible contact states ensuring the generation of consistent contact state sets.

This paper describes a complementarity based time-stepping scheme in Featherstones Divide and Conquer framework [1,2] to efficiently model the unilateral and bilateral constraints in the system. The time-stepping scheme [3] relies on impulse based equations and does not require explicit collision detection. This hybrid formulation is felt to offer some advantages over the classical approach to model inelastic collisions since the Divide and Conquer Algorithm does not require building a system mass matrix and the use of *Complementarity Methods* nominally avoids the expensive $O(2^{m_U})$ combinatorial problem of determining consistent contact states. The complementarity solvers may still incur an $O(m_U^3)$ expense in the worst case scenarios since they rely on numerical methods to solve the complementarity problem. However, in most cases, the complementarity solvers produce a solution in less than $O(m_U^3)$.

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