The $SE(3)$ Lie group framework for flexible multibody systems with contact

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The kinematic description of multibody systems makes extensive use of the notion of frames. Frame operations may be described in a systematic manner using concepts from differential geometry and Lie groups, where a frame transformation is represented by an element of the special Euclidean group $SE(3)$. Working with left invariant derivatives and a consistent spatial discretization leads to equations of motion formulated on a Lie group. Forces, strain measures, arbitrary virtual motions and velocities are expressed in the local body-attached frame such that the equations only depend on relative motions between frames [1, 2]. Kinematic joints i.e., restricted relative motion modeled as bilateral constraints [3], can be handled conveniently. Indeed, the $SE(3)$ element that describes relative transformations is invariant under superimposed Euclidean transformation. As it will be shown in this contribution, the same can be said for contact conditions written as unilateral constraints and the associated constraint gradient. The constraints are enforced using an augmented Lagrangian approach. An implicit Lie group time integration scheme is employed [4]. The mass matrices and tangent stiffness contributions of each element required for the semismooth Newton algorithm are invariant under rigid body motions. Interestingly, during the entire formulation and discretization procedure, no global parametrization of rotation is introduced and the non-linearity of the equations is reduced as opposed to other formulations.

References

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