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Two Lie group formulations for dynamic multibody systems with large rotations. In: Proceedings of IDETC/MSNDC 2011, ASME 2011 International Design Engineering Technical Conferences, Washington, USA, 28-31 August, 2011.

Abstract. This paper studies the formulation of the dynamics of multibody systems with large rotation variables and kinematic constraints as differential-algebraic equations on a matrix Lie group. Those equations can then be solved using a Lie group time integration method proposed in a previous work. The general structure of the equations of motion are derived from Hamilton principle in a general and unifying framework. Then, in the case of rigid body dynamics, two particular formulations are developed and compared from the viewpoint of the structure of the equations of motion, of the accuracy of the numerical solution obtained by time integration, and of the computational cost of the iteration matrix involved in the Newton iterations at each time step. In the first formulation, the equations of motion are described on a Lie group defined as the Cartesian product of the group of translations $\mathbb{R}^3$ (the Euclidean space) and the group of rotations $SO(3)$ (the special group of 3 by 3 proper orthogonal transformations). In the second formulation, the equations of motion are described on the group of Euclidean transformations $SE(3)$ (the group of 4 by 4 homogeneous transformations). Both formulations lead to a second-order accurate numerical solution. For an academic example, we show that the formulation on $SE(3)$ offers the advantage of an almost constant iteration matrix.

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