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RELATIVE ORBITAL MOTION ANALYSIS USING DUAL LIE ALGEBRA REPRESENTATIONS

Abstract

Spacecraft formation flying, rendezvous operations or distributed spacecraft missions are some of the very important applications which make use of the solutions for the relative orbital problem. The relative motion between a leader and a deputy is a six-degrees-of-freedom (6-DOF) motion which represents the coupling of the relative translational motion with the rotational one. The main objective of this work is the development of new relative orbital motion analysis techniques using representations based on dual Lie algebras. Taking into account the main properties of dual tensors, more precisely their Lie group and Lie algebra, our study shows that any relative motion of rigid bodies can be globally parametrized using a curve from the Lie group of the dual tensors. This result is very important and can be used to improve research in multiple connected areas. Another contribution is the construction of a complete parametrization framework that gives the possibility of developing unitary direct solutions for computation of the main motion kinematic representation entities: dual Euler-Rodrigues parameters, dual Rodrigues vector, dual Wiener-Milenkovic parameters and dual quaternions. Using rigid bases of dual vectors, we provide direct computational solutions of the above motion kinematic entities. The proposed solutions are free of coordinates and have direct implementation, both in numerical applications and in symbolical ones. The novelty of our methods over existing solutions is discussed and the main advantages are revealed. Also, algorithms that can be used to put into practice the theoretical solutions are detailed.