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# FULL - BODY RELATIVE SPACECRAFT MOTION. A MINIMAL PARAMETERIZATION USING CAYLEY-LIKE TRANSFORM

**Abstract**

The relative orbital motion between the leader and the deputy spacecrafts is a six-degree of- freedom (6-DOF) motion, which represents the coupling of the relative translational motion with the rotational one. In recent years, increasing attention has been paid to the modeling of the relative 6-DOF motion of spacecraft. Also, controlling the relative pose of satellite formation is a very important research subject. In this paper, we reveal a multi dual tensor-based procedure to obtain exact expressions for the 6-DOF relative orbital law of motion between two Keplerian confocal orbits. Orthogonal multi dual tensors play a very important role, with the representation of the solution being, to the authors' knowledge, the shortest approach for describing the complete state onboard solution of the 6-DOF orbital relative motion problem. We introduce a new approach for pose parameterization on Deputy spacecraft by using higher- order modified Cayley transforms from Lie algebra of Lie group of multi dual tensors. On obtain a new minimal parameterization for pose and motion of deputy satellite.The novelty of our approach is a new type of modified Cayley transforms and their inverse. The inverse of modified Cayley transform is a multifunction with n-branches. Based on their definitions and properties, we proved that modified Cayley transforms are very useful when dealing with motion minimal parameterizations of 6-DOF relative orbital motion of satellite, that can reach singularities. A representation theorem is provided for the full-body initial value problem. Furthermore, the real and multi dual parts are split, and representation theorems for relative rotation and translation motion are obtained. Regarding translation, a closed-form coordinate-free solution is revealed, based of generalized trigonometric function in space at constant curvature. They hold for all types of reference trajectories of the leader (elliptic, parabolic, hyperbolic) and deputy (elliptic, parabolic, hyperbolic, rectilinear). In particular, a new type of state-transition-matrix (STM) is obtained. This new STM for spacecraft relative motion is time explicit and universally applicable to elliptic, parabolic, and hyperbolic orbits.