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THE EXTENDED WAHBA'S PROBLEM IN DUAL AND MULTIDUAL QUATERNIONS

Abstract

The Wahba problem, first proposed by Grace Wahba in 1965, seeks the proper orthogonal matrix (attitude matrix, direction-cosine matrix), which minimizes a cost function built from a set of measured directions observed in a rigid body frame. This problem is essential in multiple aerospace engineering applications that typically involve finding an optimal rotation to fit a series of vector measurements. In the last decades, many methods have been proposed to solve generalized forms of Wahba's problem. This paper extends Wahba's problem to a new problem involving both the pose and state of spacecraft. This new problem is strongly connected with the parameters that can be used to describe the pose and state of rigid bodies with dual and multi-dual quaternions. When choosing a parameterization method, the number of algebraic equations and variables is a crucial criterion. Recently, dual and multidual quaternions proved to be a completely coordinate-free tool for computing rigid-body displacement and motion parameters. The present research uses the homomorphism between the special Euclidean Lie group SE3 and the unit dual and multidual quaternions Lie groups, which allows the development of a new technique for solving the extended Wahba's problem. We give a detailed novel procedure that evaluates the existence of a solution to the previous issue. Based on this procedure, closed-form, coordinate-free solutions are obtained, thus highlighting the advantages of working in space or dual and multidual quaternions. This new Wahba problem relates to different applications, such as generalized point-to-point registration (pose and state estimation in relative orbital motion) and generalized sensor calibration problems in astrodynamics (space robotics).