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Author: Mr. Mingming Wang
Technical University of Munich, Germany

Prof. Ulrich Walter
Technical University of Munich, Germany

JOINT-SPACE DYNAMICS ALGORITHM OF SPACE MANIPULATORS WITH TREE STRUCTURE BY USING INERTIA MAPPING MATRIX

Abstract

Due to the particular harsh environment of space and the increasing demands of satellite maintenance, on-orbit refueling and assembly etc., the application of space robot has been received significant attention. In the last decades, numerous contributions have been made in the field of robot dynamics. From a systemic viewpoint, however, multi-body dynamics algorithm should be formulated with a compact set of equations for ease of development and implementation, while the greatest computational efficiency is obtained synchronously.

This study, which is critically relevant to the development of appropriate trajectory planning and control algorithms, focuses on a modeling scheme that uses the concepts of graph theory and spatial vector for calculating the joint-space dynamics of tree structure space manipulators. Firstly, the configuration description of space manipulators using graph theory, the parent array, and path matrix is introduced. Secondly, based on the concept of augmented link, the equivalence between augmented link and spatial vector is derived. The forward kinematics and differential kinematics are analyzed by using the Direct Path Methods (DPM) with spatial vector. Thirdly, the Composite Rigid Body Algorithm (CRBA) is exhibited. The Inertia Mapping Matrix (IMM) is then derived from the path matrix, which can be used to analyze the sparsity of the inertia matrix and the complexity of the algorithm. Within the context, a modified CRBA combines ideas of IMM and spatial vector is proposed to calculate the dynamics of tree structure space manipulators. Its computational procedure and complexity by using IMM are analyzed. Finally, a case study and comparison by using a humanoid configuration for branched and un-branched chains particularly verify the effectiveness and potential of the proposed modified CRBA for the space manipulators.