ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics - Part 1 (5)

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DYNAMICS OF A RIGID MULTIBODY SYSTEM WITH LOOP CONSTRAINS USING ONLY INDEPENDENT MOTION VARIABLES

Abstract

In the last tens of years, numerous efforts have been made in the dynamical formulation of hinge-connected multibody systems such as robots, spacecrafts and mechanisms. Recursive formulations are commonly preferred for dynamical simulation due to the high computational efficiency. However, for system controller design, the direct formulations are usually required which contains explicit expressions of the system mass matrix and nonlinear forces. The objective of this paper is to present such a direct formulation for a rigid multibody system connected by hinges which allow large angle rotations with loop constrains; and moreover, only independent motion variables appear in the equations, which implies that the dimension of the equations is equal to the number of degrees of freedom. A tree configuration is firstly acquired by cutting one of the loop body in half, and the motions of the tree configuration system are described by the translation and rotation of an arbitrarily selected base body and the rotation of each branch body relative to its inner body. Based on a matrix version of Kane's dynamical equations, general equations of motion are formulated where each branch body is allowed to have three degrees of freedom of relative rotation. Of course, for some hinges such as revolute and Hooke's joints, the degrees of freedom of relative rotation is less than three, and such joints can be applied by projecting the general equations into lower dimension using the kinematic equations of the joints without modifying the general equations. For the system with loop constraints, the equations of full order, in which the time derivatives of all generalized speeds appear in the equations, is firstly obtained using a new form of Kane's equations for constrained system without introducing any multipliers. Then, by expressing the generalized speeds in terms of the independent ones, the equation order is reduced such that only independent generalized speeds appear in the equations. A numerical simulation based on a space robot is carried out using both the formulations presented and the dynamic software ADAMS, and the results demonstrate the approach of this paper. The equations of motion presented for the loop constrained system have a similar direct form of that of a unconstrained system, and the explicit expressions of the system mass matrix and nonlinear forces are presented which can be applied to various systems just by specifying system configuration, type of joints and the constraint equations.