623. Computer algebra for solving dynamics problems of piezoelectric robots with large number of joints

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Abstract. The application of general control theory to complex mechanical systems represents an extremely difficult problem. If industrial piezoelectric robots have large number of joints, development of new control algorithms is unavoidable in order to achieve high positioning accuracy. The efficiency of computer algebra application was compared with the most popular methods of forming the dynamic equations of robots in real time. To this end, a computer algebra system VIBRAN was used. Expressions for the generalized inertia matrix of the robots have been derived by means of the computer algebra technique with the following automatic program code generation. As shown in the paper, such application could drastically reduce the number of floating point product operations that are required for efficient numerical simulation of piezoelectric robots.

Keywords: Computer algebra; piezoelectric robots; real-time dynamics; numerical-symbolic computation.

1. Introduction

If industrial piezoelectric robots have large number of joints, the application of such a theory and development of new control algorithms are unavoidable in order to achieve high positioning speed and accuracy. In on-line control, the calculation of model equations must be repeated very often, preferably at sampling frequency that is not lower than 50 Hz. It appears to be necessary to develop computer methods of mathematical modeling for at least two reasons. One of them is that it is impossible to immediately choose the most convenient configuration when designing robots. Thus, it is necessary to analyze a number of different robot configurations and select the most appropriate to the future purpose of the device.

Knowing how complex is a task of writing a mathematical model by hand, the need for an algorithm that would enable a computer to perform the task seems quite logical. The other reason is the need in multiple applications for real-time control of robots. The development of computer methods, such that perform real-time calculations of robot dynamics, is a direct contribution to the synthesis of control algorithms for practical purposes [8, 14, 15].

Manipulator and robot systems possess several specific qualities in both mechanical and control sense. From the mechanics point of view, a feature that is specific to manipulation robots is that all the degrees of freedom are "active", i.e., powered by their own actuators, in contrast to conventional mechanisms in which motion is produced primarily by the so-called kinematics degrees of freedom. Another specific quality of such a mechanism is their variable structure, ranging from open to closed configurations, from one to another kind of boundary conditions. A further feature typical of spatial mechanisms is redundancy reflected in the excess of the degrees of freedom for producing certain functional movements of robots and manipulators. With respect to control, robot and manipulator systems represent redundant,