SOLVING THE DIRECT AND INVERSE PROBLEM OF THE DYNAMICS OF A SPATIAL THREE-LINK MANIPULATION ROBOT IN THE MAPLE SYSTEM

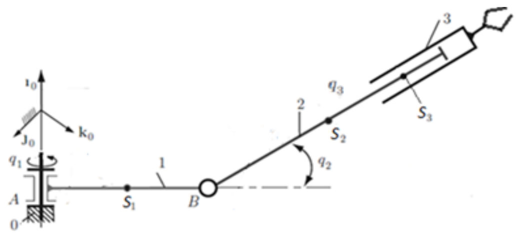
A.K. YERALIEV

Al-Farabi Kazakh National University, Almaty, Kazakhstan
e-mail: ablay_e@mail.ru

In dynamic research of the robot manipulator, it is important to find a solution to two types of problems related to the calculation of forward and reverse dynamics [1,2].

Direct dynamics makes it possible to describe the movement of a real physical system based on the angular acceleration of the hinges (kinematic pair (KP)) when a set of specified generalized moments is applied to the manipulator; generalized velocities and positions of KP can be obtained using Lagrange equations. These equations give an analytical relationship between the driving moments in the end-effector (and the forces acting on the working body) and the positions, velocities and accelerations of the links.

The solution of the inverse dynamics problem can be used to plan the trajectory of the manipulator and implement a control algorithm. Once the trajectory of the KP is defined in terms of positions, velocities and accelerations and if the forces acting on the KP are known, the reverse dynamics allows us to calculate the driving moments that must be applied to the KP to obtain the desired movement.



The article discusses the RRT robot manipulator (see Figure), consisting of three links 1, 2 and 3. Link 1 can be rotated by an angle $q_1(t)$ around the vertical axis i_0. Link 2 rotates around an axis passing through B and perpendicular to axis 1. The last link 3 is connected to 2 by means of a translational pair. The centers of mass of links 1, 2 and 3 are S_1, S_2 and S_3, respectively. The position of the 2nd link relative to the first is determined by the generalized coordinate $q_2(t)$, and the position of the 3rd link relative to 2 $q_3(t) = l_{S_2 S_3}$.

During the dynamic research of this robot in the Maple analytical computing system, programs were compiled and found: transformation matrices R_{ij} for each link; angular velocities and accelerations of the links ω_{ij} and ε_{ij}; position vectors r_{S_i}, velocity v_{S_i} and acceleration a_{S_i} of the centers of mass S_i of the links; generalized (active) forces Q_i; Lagrange equations of motion of the second kind.

Further, using these results, the direct and inverse problem of the dynamics of a manipulative robot was solved numerically. These programs and results can be used in the educational process.

Keywords: Dynamics, manipulation robot, Maple symbolic computing system.

AMS Subject Classification: 70E60, 70E55.

References

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[2] Siciliano B., Sciavicco L., Villani L., Oriolo G., Robotics Modelling, *Planning and Control, Springer*, 2009. 644 p.