Journal of Modern Technology and Engineering
Vol.4, No.2, 2019, pp.132-136

TRAFFIC CONTROL OF THE INTELLECTUAL ROBOT MANIPULATOR BUILT ON THE BASIS OF A MULTICOORDINATE MECHATRON MODULE

H.N. Nazarov[1*], **T.O. Rakhimov**[2]

[1]Tashkent State Technical University named after Islom Karimov, Tashkent, Uzbekistan
[2]Tashkent University of Information Technologies named after Muhammad al-Khwarizmi, Tashkent, Uzbekistan

Abstract. The paper considers the mathematical model of dynamics and kinematics of robot technological movements, identifying the basic motions of the six-motion robot in managing the manipulator based on the technology of the intelligent robot based on associative memory technology. Mathematical analysis of the measurements of each movement is given.

Keywords: Intelligent robot, associative memory, manipulator, rectilinear motion, angled movement, multicolored mechatronics module, stepper motor, technological movements.

Corresponding author: Temurbek Rakhimov Omonboyevich, Lecturer of Urgench branch of Tashkent University of Information Technologies named after Muhammad al-Khwarizmi, Tashkent, Uzbekistan
e-mail: *rahimov_timur@bk.ru*

Received: 07 May 2019; Accepted: 22 June 2019; Published: 07 August 2019.

1 Introduction

As a result of the development of mechatronic systems, the share of industrial robots in basic technological processes is also rising. At the same time, the cost of capital, however, will increase as a result of increased workplaces and quality of work. In addition, social effects are achieved through the operation of mechatronic systems that are harmful to human (shooting, welding, etc.) and monotonous operations (conveyor collection) (Zimina et al., 2016).

Information technologies of the expert systems, associative memory, fuzzy logic and neural networks seem to be the most promising for creating intelligent control systems for robots built on the basis of multi-coordinate electromechatronic modules (Satapathy et al., 2013; Zimina et al., 2016).

The paper discusses the formation of motion control of an intelligent robot when performing a wide class of a manipulator of processes based on associative memory technology.

2 Materials and Methods

When implementing the process manipulator, the robot performs the following technological movements:

- Movement along an arbitrarily specified trajectory (DPZT);
- Movement along a given trajectory in the horizontal plane (PG);
- Movement along a predetermined trajectory in a vertical plane (PV);
- Rectilinear motion at any angle (PD);
- Horizontal rectilinear motion (GD);

- Vertical straight motion (VD);
- Orientation of the gripping device (OZ);
- Rotation of the gripping device (RZ).
- The operation of the gripping device (SZ).

As mathematical models of technological models of technological movements of a robot, we consider the equations of dynamics and kinematics of the robot, and the equations in increments that are most convenient for the analysis of kinematics equations (Satapathy et al., 2013; Nazarov, 2005).

Since the proposed technological movements form nested sets (Fig. 1), we begin with the construction of mathematical models with a set that unites the largest number of types of movements - DPST.

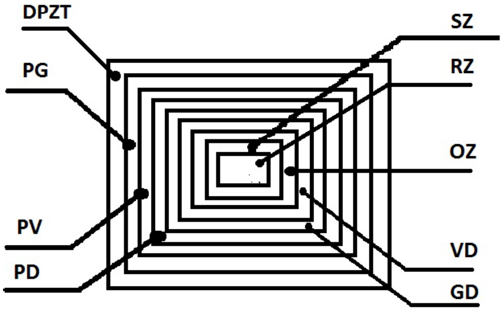

Figure 1: Diagram of the nested sets of technological movements of the robot arm.

The general equation of the dynamics of a robot built on the basis of a multi-coordinate module with six coordinates is

$$\sum_{k=1}^{6} G_{jk}\ddot{q}_k + \sum_{k,l}^{6} G_{jkl}\dot{q}_k\dot{q}_l = M_{jd} + M_j, \tag{1}$$

$$u_j = k_b\dot{q}_j + \frac{R_R M_j}{k_m} + \frac{L_R}{k_m} \times \frac{dM_j}{dt}, \tag{2}$$

$$p_j = N_j(q_1, ..., q_6), \tag{3}$$

$$p_j = F_{jk}(p_k), \quad j = 1, 2, ..., 6, \quad k = 1, 2, ..., 6, \tag{4}$$

$$u_j = f_j(q_1, ..., q_6, \dot{q}_1, ..., \dot{q}_6, \ddot{q}_1, ..., \ddot{q}_6, q_1^{(m)}, ..., q_6^{(m)}). \tag{5}$$

For DPT, equations (1), (2) are true, reflecting the dynamics of the drives, (3) - the kinematics of the robot, (4) - the trajectory of the technological movement and (5) - the control actions on the executive electric motors. Usually, all six degrees of mobility are involved in the realization of motion, therefore n = 6, and it is not possible to simplify the equations (Klimov, 1999). However, taking into account that between two points on a trajectory of movement in the reference coordinate system, movement along splines is performed, kinematics equation (3) can be rewritten as

$$\dot{q}_j = \sum_{k=1}^{6} J_{kj}(q_1, ..., q_n)\dot{p}_k. \tag{6}$$

For PG, equations (1) - (4) are valid with restrictions due to the nesting of technological movements.

The absence of rotation and a fixed orientation in space of the movement of the gripping device correspond to the equality to zero of the speeds:

$$\dot{p}_4 = \dot{p}_S = \dot{p}_G.$$

The system transforms equation (6) as follows:

$$\dot{q}_j = \sum_{k=1}^{2} J_{kj}(q_1, ..., q_n)\dot{p}_k.$$

For PV, expression (6) takes the form

$$\dot{q}_j = I_{1j}(q_1, ..., q_6)\dot{p}_1 + I_{2j}(q_1, ..., q_6)\dot{p}_2 + I_{3j}(q_1, ..., q_6)\dot{p}_3. \tag{7}$$

The equation of the trajectory in the projection on any of the planes of the reference coordinate system turns to

$$\dot{p}_2 = b_{21}\dot{p}_1. \tag{8}$$

Substituting (8) into (7), we obtain the kinematic equations for PV

$$\dot{q}_j = (I_{1j}(q_1, ..., q_6) + I_{2j}(q_1, ..., q_6)b_{21})\dot{p}_1 + I_{3j}(q_1, ..., q_6)\dot{p}_3, \tag{9}$$

In straight-line motion at any angle, the kinematic equation will take the form

$$\dot{q}_j = (I_{1j}(q_1, ..., q_6) + I_{2j}(q_1, ..., q_6)b_{21} + I_{3j}(q_1, ..., q_6)b_{31})\dot{p}_1. \tag{10}$$

For the vertical and horizontal rectilinear motions, equation (10) is simplified, since the corresponding coefficients of the projections are zero in pairs. The operation of the gripping device and its rotation are additional degrees of mobility that are not associated with movement along a given trajectory.

Thus, when developing the trajectories of motion of the gripping device of the assembly robot in accordance with nine technological movements, the solutions of the kinematic problem and the calculation of the velocities of the generalized coordinates are simplified significantly, and in accordance with the statement and its consequence - the equations for the formation of control actions. Replacing with a linguistic approximation of a real trajectory technological movement allows you to predict the behavior of a dynamic system and select from the base of models and controls the corresponding control algorithm.

As an example of the formation of a linguistic approximation of technological movements, consider the process of assembling a stepper motor.

The robot operates in a spherical coordinate system, has three links and seven degrees of mobility. Assembly of the electric motor and parts is carried out on a unified cassette. One part of the parts (rotor, washer, ball) is located in the special holes of the top panel of the cassette, the other part (cover, spring, stator) is mounted between the technological pins of the same panel (Gomilko, 2016).

The process of robotic assembly in accordance with the process map is divided into the following operations:

1) insert the rotor of the electric motor into the washer (tight seating);

2) the compound obtained after performing step 1 is placed in the stator;

3) put the ball on the rotor and press the rotor into the stator until it stops (the landing is tight);

4) tighten the ball with a spring, which is removed from the pins, compressed and installed in the special grooves of the stator;

5) close the assembly after operation 4 with a lid pre-lubricated with glue.

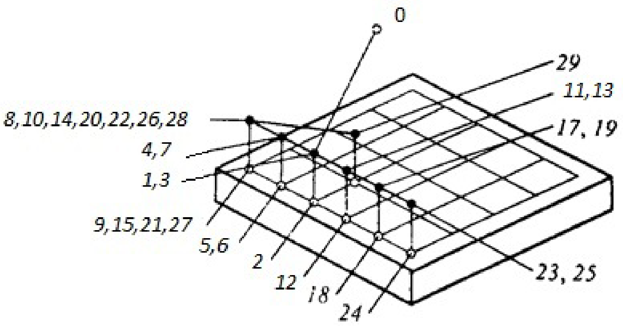

Figure 2: Diagram of the movement of the intelligent robot arm when assembling a stepper motor.

The assembly is carried out using a snap-in made in the form of a special fixture. It consists of two parts, which are fastened with four screws to the gripping jaws and are special-type grippers. All operations, except for operation 4, are performed by the first part of the gripping device. Operation 4 is carried out by the second part of the gripping device after turning the device to 180^0. In Table 1 shows the reference points and technological movements of the robot, ensuring the implementation of the assembly process of a stepping motor in accordance with the technological map. The motion diagram of the robot arm is shown in (Fig. 2)

3 Result

Table 1: Anchor points and technological movements of the robotized assembly process of a stepper motor

Trajectory points	Robot movement	Movement type
0, 1, 2	The transition of the initial position to the first part - the rotor	SZ, VD
2, 3	Capture and raise the rotor above the cassette	DG
3,4	Moving the rotor to the position ”washer”	VD
4, 5, 6	Installing the rotor in the washer (landing tight)	VD
6, 7	Lifting the washer and rotor	DG
7, 8	Transferring the washer and rotor to the stator position	WD, NW
8, 9	Installing the washer and rotor in the stator	VD
9, 10	Lifting grip	DG
10, 11	Moving the gripper to the ball position	WD, NW
11, 12	Lowering the grabber and grabbing the ball	VD
12, 13	Ball lift	DG
13, 14	Ball transfer to stator position	WD, NW
14. 15	Install the ball in the stator	VD, OZ
15, 16	Raise and rotate gripper	DG
16, 17	Moving the gripper to the spring position	WD, NW
17, 18	Lowering the gripper and gripping the spring	VD
18, 19	Lifting grip with spring	DG
19, 20	Transferring the spring to the stator position	WD, NW
20, 21	Lowering the gripper with a spring and installing it in the stator	VD, OZ
21, 22	Raise and rotate gripper	DG
22, 23	Moving the gripping device to the “cap” position	WD, NW
23, 24	Lowering the grab and locking the lid	VD
24, 25	Raise the cover over the cassette	DG
25, 26	Moving the cover to the stator position	VD
26, 27	Installing the cover on the stator	PD
27, 28	The next transition to the “rotor” position for assembling a new electric motor	SZ, VD

4 Conclusion

Thus, the analysis of intelligent control technologies of robots built on the basis of multi-coordinate mechatronic modules shows that the most promising technology for robotization of the process manipulator is the control technology based on associative memory. Robotics is the future of technology and science and the control technology based on associative memory.

References

Gomilko, S., Zimina, A. & Shandarov, E. (2016). Attention training game with aldebaran robotics NAO and brain-computer interface. In *International Conference on Interactive Collaborative Robotics*, 27-31. Springer.

Klimov, D. (1999). Programm of R & D on micro machines, micro robots, and micro systems, *Proc. International Workshop on Micro Machines, Micro Robots & Micro Systems*, 15-25 (in Russian).

Nazarov, H.N. (2005). Intellectual multicoordinate mechatronic modules of linear motion of robotic systems. *Mechatronics, Automation, Control*, 4, 26-31 (in Russian).

Satapathy, S.M., Kumar, M. & Rath, S.K. (2013). Fuzzy-class point approach for software effort estimation using various adaptive regression methods. *CSI transactions on ICT*, *1*(4), 367-380.

Zimina, A., Rimer, D., Sokolova, E., Shandarova, O. & Shandarov, E. (2016, August). The humanoid robot assistant for a preschool children. In *International Conference on Interactive Collaborative Robotics*, 219-224, Springer.