Journal of Modern Technology and Engineering
Vol.5, No.2, 2020, pp.181-187

PRINCIPLE OF CONSTRUCTION OF INTELLECTUAL MULTICORDINATE MECHATRONE MODULE WITH POWER MOMENT SENSITIVITY

Kh.N. Nazarov, T.O. Rakhimov*

Department of Electronics and Automation, Tashkent State Technical University named after Islom Karimov, Tashkent, Uzbekistan

Abstract. The article discusses the concept of a mathematical description of the multi-coordinate mechatronic modules of robots. The main results of the work are the generalized structure of the multi-coordinate mechatronic motion module, a kinematic scheme of the electromagnetic multi-coordinate mechatronic module with three independent coordinate of linear and angular movements. The important aspect of the study is the use of a multi-coordinate mechatronic motion module in robots, which makes it possible to obtain several linear and angular coordinates in one module at the output. There are no constructive solutions in the literature for a similar purpose. The proposed concept of the mathematical description of the multi-coordinate mechatronic module is original, which are oriented to display their structural and operational features.

Keywords: Solenoids, manipulator, mechatronic module, motion, multi-coordinate module, robots, position module.

Corresponding author: Rakhimov Temurbek Omonboyevich, Department of Electronics and Automation, Tashkent State Technical University named after Islom Karimov, Tashkent, Uzbekistan,
e-mail: *Rahimov_timur@bk.ru*

Received: 23 February 2020; Accepted: 12 June 2020; Published: 30 August 2020.

1 Introduction

Currently, in engineering and technology the development of the multi-coordinate mechatronic systems that perform power and control functions is becoming of paramount importance. This is due to a number of important positive qualities of the systems such as simplicity and compactness of the design, the possibility of obtaining significant efforts, high accuracy and stability of the establishment of fixed positions, ease of control and high reliability. In some including Japan, South Korea, the USA, Germany, Sweden, Russia, etc., special attention is paid to the construction of intelligent robots and mobile systems based on mechatronic modules with qualitatively important functions and properties, a priori oriented towards functioning in conditions of incompleteness and fuzziness of the initial information and the uncertainty of external disturbances.

Much attention is paid to the creation of universal multi-coordinate mechatronic modules that can simultaneously receive several output actions in the form of linear and angular movements, since multidimensional mechatronic actuating systems with two or more output linear movements are insufficiently studied. Usually, electromagnetic actuators of multidimensional control systems are constructively created separately for each regulatory body, which leads to unjustified complication of the system.

A distinctive feature of modern development in the management of the intelligent multicore coordinate, the multi-output mechatronic modules (MMM) is the optimization of their functional motion control processes. The technical implementation of the intelligent moving MMMs has been made possible in recent years due to the rapid development of microprocessor systems focused on motion control problems (Kazakov, 1991; Yurevich, 2000).

2 Literature Review

Today, measures are being taken in the Republic of Uzbekistan to effectively organize the system of technological processes and emissions management. The world's leading research centers and universities, including Bergen Laboratories Ins, Michigan General Electric University (USA), Sony and Tokyo Institute of Technology, Tashkent State Technical University named after Islam Karimov (Uzbekistan) are conducting research on current issues in the development of mechatronics. The growing demand for intelligent systems of automatic control requires the use of multi-coordinate mechatronic systems, where the initial data are incomplete or inaccurate, the main focus is on working in an uncertain environment, unconventional approaches to management, absolutely requires the use of new technologies (Kazakov, 1991; Yurevich, 2000; Nazarov & Xasanov, 1996). Intellectual mechatron module is a mechatron module that can move independently in an unknown environment. They respond to some of the uncertainties of the situation using any technical means and adapt their actions to them in carrying out the technological tasks. In other words, by sensing the state of the environment in some way, the mechatron module should automatically generate a set of control signals to these manipulator devices, regardless of the uncertainties present in the external environment.

3 Materials And Methods

Electromagnetic multi-coordinate mechatronic motion modules make it possible to obtain many linear and angular motions at the output.

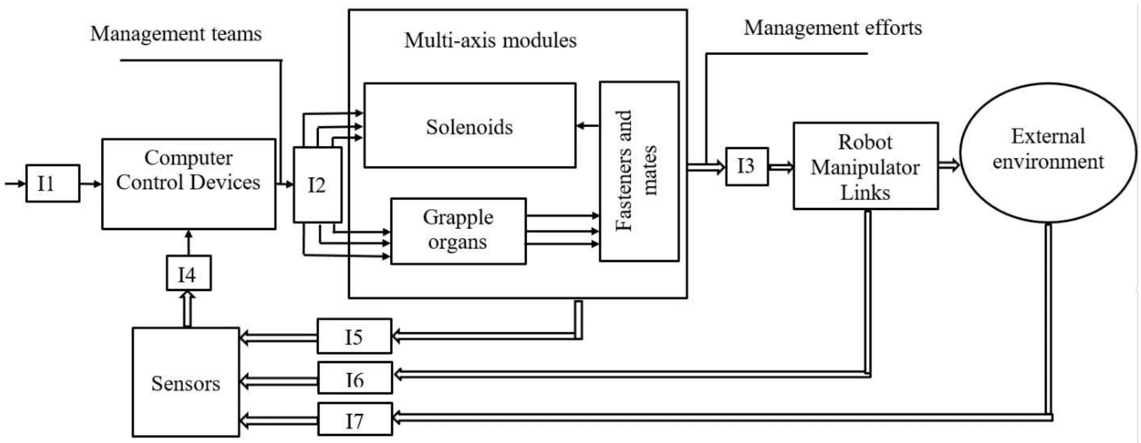

Figure 1: Generalized structure of intelligent multicore coordinate mechatron modular system

Continuous improvement of production technologies leads to a stable decrease in the cost of hardware, which has made them by now cost-effective for the practical implementation of EMMM (Nazarov et al., 2019; Nazarov & Matyokubov, 2018).

The generalized structure of the EMMM system of automatic control is shown in Figure 1.

The computer control device (CCU) based on the input information coming from the upper control level and through the feedback circuits from the sensors; issues control electric signals to the multi-axis actuator modules in time. In power converters, power amplification of these signals and their modulation occur. Then, the executive modules generate the corresponding efforts (forces and moments) for the links of the robot, which as a result provides the targeted movement of the final link of the work - its working body.

To interface the elements, special interface devices I1, I2, I3, I4, I5, I6, I7 are introduced into the system.

Let us look at examples of interlock interfaces that are most often found in computer-controlled robots that are widely used in automated production. Interface I1 is a set of network hardware and software tools for interfacing computer control devices with a computer network, or a human-robot interface, if the control goal of the mechatronic system is set directly by the human operator. Modern human-machine interfaces are implemented in the form of remote controls and handles for remote control (for example, for programming industrial robots by the teaching method) of touch display devices for displaying information in virtual reality systems.

The I2 interface usually consists of a digital-to-analog converter and an amplifying-converting device and serves to generate control electric voltages for the executive modules.

The I3 interface is, as a rule, mechanical transmissions connecting the executive modules with the links of the robot. Structurally, such transmissions usually include gearboxes, couplings, flexible couplings, brakes, etc.

The I4 interface at the UCF input, if sensors with an analog output signal are used in the mechatronic module, is based on analog-to-digital converters.

The interfaces of the sensors I5, I6 and I7, depending on the physical nature of the input variables of the state of the system, can be divided into electrical and mechanical. Mechanical devices include connecting devices for module feedback sensors (photo pulse, code revolvers, etc.), torque and tactile sensors, as well as other sensing tools and information about the movement of modules, robot links. It should be noted that the connection of all elements with a computer control device involves not only hardware pairing, but also appropriate software for organizing real-time data exchange (Nazarov & Matyokubov, 2018).

4 Results

There are three directions of MMM intellectualization:

- development of built-in interfaces that connect the control panel to a high-level computer, a single hardware-software control complex (interface II);
- creation of intelligent power management modules by combining control controllers and power converters (I2 interface);

In addition to the usual measurement functions, the development of intelligent sensors of mechatronic modules that perform computer processing and signal conversion using flexible software (I3 interface).

The principle of construction of multi-axis mechatronic modules of linear motion is based on the provision of the moving part of the electromagnet (armature) with several separate controlled bodies of gravity.

The MMM consists of a control device, blocks of electromagnets and permanent magnets, traction bodies (otherwise controlled couplings) and fastening and fastening elements.

Electromagnets are used to transmit input electrical signals to the mechanical movements of the interaction, to the gripping organs and interface elements - the moving organs of the robotic system. Permanent magnets are moving parts of these electromagnets. The number of connecting bodies corresponds to the number of moving joints of the robot.

The interaction mechatron module at the output of the electromagnet is converted into a set of linear and angular motions connected by the gravitational organs and (or) the interface of the motion bodies.

The mechatron module has four electromagnets with a cylindrical shape and permanent magnetic cores (in the general case the module can have more than four electromagnets). The working bodies of the 4-handle are rigidly connected to the moving permanent magnets and are designed to transmit the interaction of the moving parts of the electromagnets to the output rods, which in turn are connected and led by the joints of the robot. move them in a linear motion.

As can be seen from Figure 2, each rod made of non-magnetic material corresponds to the two working bodies of the handle. Each group of gravitational bodies of the same type has rigid mechanical connections.

The control signals are delivered to each holder separately so that rows 1 and 3 perform coordinate movements independently of each other.

The direction of the coordinate motion depends on the law of variation of the control signals received from the computer control device. The kinematic scheme of a multi-coordinate mechatron module with a force torque sensitivity sensor is shown in Figure 2.

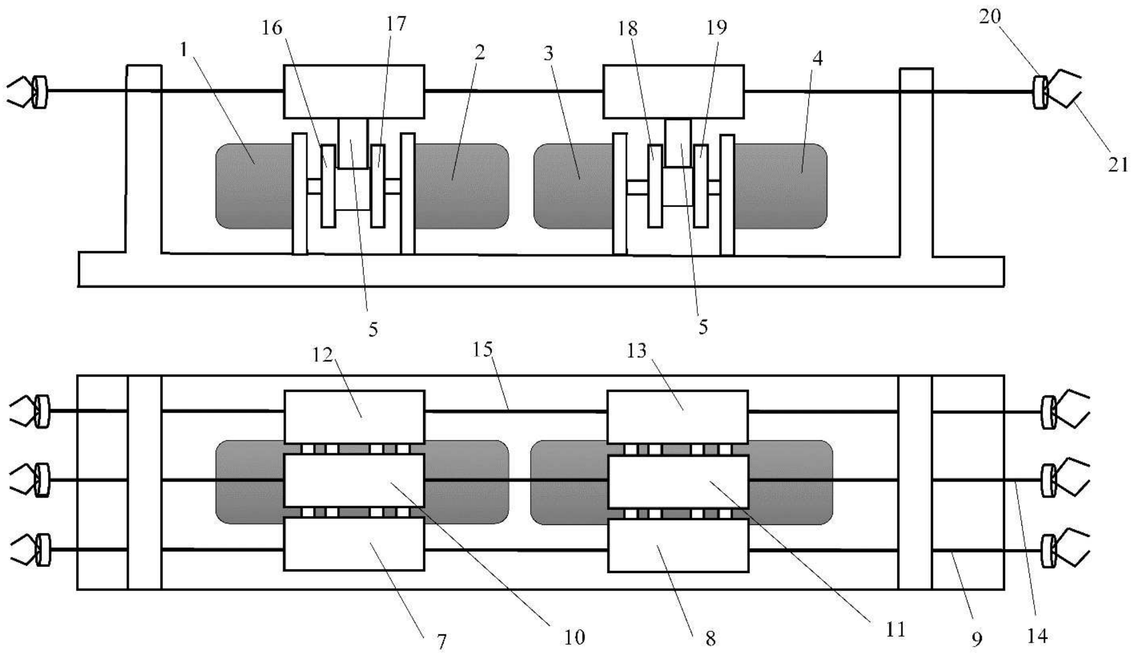

Figure 2: Kinematic scheme of a multi-coordinate mechatronic module with a force torque sensitivity sensor

The construction of a multi-coordinate mechatron module with three outputs is shown in Figure 2. The power sensitivity includes four electromagnets of types 1, 2, 3 and 4, and 16, 17, 18, 19 of which have two moving parts. 7, 8, 10, 12, 11, 13 Three pairs of electromagnetic couplings 5, are fixed to the moving parts by means of lines, which are closed (at the bottom) in the form (not shown in the figure) and 9 in the form of a single rigid rod, two flexible stock connected to 9.

By installing different control contours on the electromagnetic clutches 7, 8, 10, 12, 13, it is possible to obtain independent contours of movement in the stock 9, 14, 15, i.e. progressive step movements. In the circuit, 20 Power torque sensors are 21 couplings that allow you to control the level of sensitivity, movement.

The principle of operation of electromagnetic windings is similar to that described in (Kazakov, 1991) and consists in ensuring that the couplings are firmly attached to the moving parts of the multi-coordinate mechatron module when they are switched on, i.e. when a constant voltage is applied to their rising parts. Electromagnetic windings perform the functions of mechanical switches that transmit the interaction of moving parts to the shafts, alternating switching on and off to ensure that the interactions are converted into translational motions.

5 Discussions

The simplest tool in mechatron modules of power torque sensitivity sensors in the circuit is a very convenient device, sensing contacts and a good impression device. The vertical deflection pin (fingerprint) that rotates on the mechatron module brush obtains the angular deflection when in contact with the part, which is a signal in the mechatron module control system that indicates its presence and location. If necessary, in this way, in very simple cases, it is possible to separate parts of the same size (for example, shafts of different diameters) and use them in technological processes for subsequent transmission.

Such sensitivity sensors (sensor systems) can be further classified as follows:

- tactile systems that allow the manipulator to touch when in contact with any object;
- power or torque sensor devices that allow the manipulator to sense a range of forces when measuring objects and forces acting in a plane or spatial coordinate system when in contact with objects;
- vision systems that allow the robot to control the situation and objects by automatically making decisions about the necessary actions of the robot in a recognized situation to control the operating process or directly regulate its execution.

In the field of Robotics, which we are focusing on, based on the use of force torque sensitivity sensors to measure forces and moments, robotic power sensing systems play an important role. They are useful when an object or tool mounted in the robot's hand comes into contact with other objects in the technological process.

In fact, the principles of measuring power and building torque-sensing sensors are different. Most often, traction gauges are used, the jaws of the handle or the robotic brush are attached to the elastic elements of the mechanism, or the parts are located. However, multi-coordinate mechatronic modules and magnetoelastic sensors with power torque sensitivity can also be used. Sometimes the principle of measuring the small displacements of the calibrated sides of the sensor under the influence of external forces is applied in the process of contact with the working object of the compression device or the device mounted on it.

The power torque sensitivity sensors in multi-coordinate mechatronic modules can be set separately in a specific direction to measure power or torque. But there are also multi-component sensors: three-component (measuring three projections of arbitrarily directed force or measuring two projections of force and torque) to measure three power projections of six components and three moments of torque are also used.

An example of a force torque sensitivity sensor with simple mechanical separation of the components of the force and torque vectors is shown in Figure 3. This sensor is located under the fingers of the manipulator and is slightly larger.

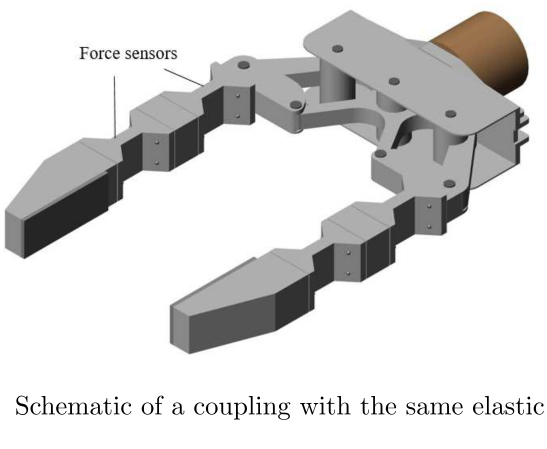

Figure 3: Schematic of a coupling with the same elastic elements

In this figure (two elements of each jaw of the coupling) the compression force on the coupling and the coordinate of the location of the captured object are determined by a correspondingly smaller dimension.

As an example, when assembling a shaft-bushing element, the robotic arms set the parts with sufficient accuracy. Some misalignments and misallocations of parts (Fig. 4) lead to the appearance of certain contact forces when approached. Based on the generality of the measured components of the forces, the control system of the assembly device determines how to eliminate incompatibilities and disparities with the help of motors.

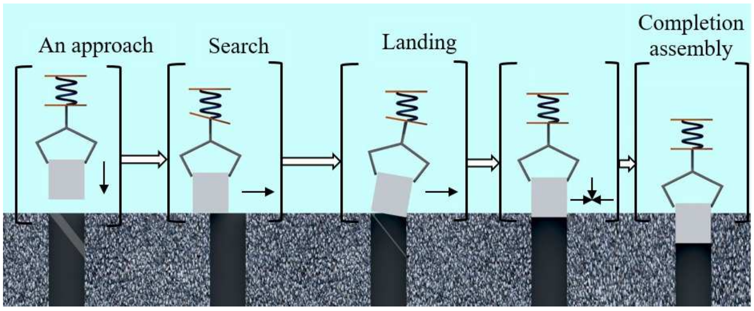

Figure 4: Assembly process diagram

Proximity power torque sensitivity sensors, often ultrasonic (other small-sized devices can also be used) located in the robot's arm to place the coupling on any object. One emitter and two receivers of the reflected signal determine the distance to the object and the angle of inconsistency of the coupling axis and the direction to the object in the same plane.

6 Conclusion

Thus, multi-coordinate mechatronic modules with power moment sensitivity sensors are widely used in industry. In controlling the motion of multi-output mechatron modules, the power torque sensitivity sensors have a good effect on increasing the output efficiency which in turn enriches the product volume.

References

Afonin, A.A., Grebennikov, V.V. (1981). *Linear Electromagnetic Drive and Calculation of Their Static and Dynamic Characteristics.* Preprint, Kiev, 55 p. (in Russian).

Kazakov, L.A. (1991). *Electromagnetic Devices RAA*: Handbook. Moscow, Radio I Svyaz, 352 p. (in Russian).

Krutko, P.D. (1991). *Control of Executive Systems of the Robots.* Moscow, Nauka, 281 p. (in Russian).

Nazarov, Kh.N, Rakhimov, T.O. (2019a). Traffic control of the intellectual robot manipulator built based on a multicoordinatemechatron module. *Journal of Modern Technology and Engineering, 4*(2), 132-136.

Nazarov, Kh.N. (2005). Intelligent mechatronic modules of the linear motion of the robototechnical systems. *Mechatronics, Automation and Control*, 4, 26-31 (in Russian).

Nazarov, Kh.N. (2019). *Intelligent Multi-Axis Mechatronic Modules of the Robototechnical Systems.* Toshkent: Mashxur-Press, 143 p. (in Russian).

Nazarov, Kh.N, Abdullaev, M.M., Rakhimov, T.O., Otamuratov, S.Sh. (2019). Mathematical description of the construction principles of electromagnetic mechatronic modules of intelligent robots. *International Journal of Engineering and Advanced Technology, 9*(2), 1001-1005.

Nazarov, Kh.N, Matyokubov, N.R.(2018). Models of multi-ordinary mechatronic models of intellectual robots. *Chemical Technology, Control and Management, 2018*(3), 150-153.

Nazarov, Kh.N, Rakhimov, T.O. (2019b). Mathematical models of multi-coordinate electromechatronic systems of intellectual robots. *Electronic Journal of Actual Problems of Modern Science, Education and Training,* 3, 37-46.

Nazarov, Kh.N., Xasanov, P.F. (1996). Industrial Robot. Patent, No.1598380, N02K33/02, 27.11.1996, BI No.23.

Nazarov, Kh.N. (2006). On the concept of constructing multi-axis mechatronic modules for the movement of intelligent robots. *Chemical Technology. Control, Management*,5, 5-7 (in Russian).

Yurevich, Ye.I. (2000). *Control of Robots and Robototechnical Systems*. Sankt-Petersburg, 170 p. (in Russian).

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