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METHOD OF THE AUTOMATED DETERMINATION OF GRIPPERS SUPPORTING POINTS COORDINATES IN INDUSTRIAL ROBOTS IN THE SYNTHESIS OF ASSEMBLY TECHNOLOGY

The process of designing robotic mechanical assembly technology (RMST) involves solving many problems. One of them is automated determination of the coordinates of supporting points (CSP) of grippers trajectory space (Gr) in industrial robots (IR), when servicing main (MTE) and auxiliary (ATE) technological equipment of flexible manufacturing cells (FMC).

Nowadays they do not pay special attention to the scientific substantiation of determination of IR Gr CSP, though the introduction of robotics as such is an important step to saving financial, time and other resources in assembly technology automation. Most often a starting point of IR Gr is randomly chosen and end point is determined by the corresponding movements from technological equipment (TE) to Gr poles.

Well-known approaches to determining CSP Gr IR (vector method of the manipulator kinematic analysis, the method of matrix, the method of screws and dual matrix), require a certain qualification training of developers, users. They require a designer's perfect knowledge of powerful mathematical packages and has a number of drawbacks:

- these methods take into account the geometric parameters of IR links, but they do not consider the Gr location and Gr geometric parameters in each of the points in time when moving between supporting points, namely its trajectory, that indicates need for further checks on possible collisions of technological robotic kit elements;
- known methods are not based on a system approach and thus do not take into account all the factors, parameters and limitations that determine the expected outcome.

The proposed method of automated determination of the coordinates of supporting points (CSP) of grippers trajectory space (Gr) in industrial robots (IR) is a continuation of the research conducted at the department of automated control of technological processes and computer technologies at Zhytomyr State Technological University. It reproduces the approach to the synthesis of sets of methods for determination of CSP of Gr trajectory space in IR based on the criterion of minimum expenses of IR kinematic resource in technological servicing of IR MTE and ATE: values of linear and/or angular Gr IR movements.

The method for determining Gr IR supporting points, which was named At-method is a set of methods of determination of Gr IR supporting points that are used depending on the relative placement of the working position in the working IR zone and consists of VII levels of RMST detailization.

At the I - IV levels depending on the location of Gr IR final supporting points sets, i.e. a set of points $(C_t \mid t = \overline{1, T^{dg}})$, when servicing each t-th working position $(WP_t \mid t = \overline{1, T^{dg}})$, where Tdg is the number of process working positions (as opposed to T which is the number of physical working positions), they developed the classification method of mutual location of final sets of Gr IR supporting points. According to this classification they distinguish relative endpoints sets position $(C_t \mid t = \overline{1, T^{dg}})$ FMC: with full crossing (C – crossing); without crossing - when Gr endpoints sets are in different parts of the IR working area and have no common crossings (NC – noncrossing); with incomplete partial crossing – when not all the investigated sets have common crossing (PC – partial crossing).

Two search options are formed for end points positioning $(C_t \mid t = \overline{1, T^{dg}})$: searching one coordinate end points (Ct) positioning of Gr IR (OC) and different coordinate (DC). One coordinate search method (OC) means determining the coordinate which is common to the working position and is in the range of the the sets common crossing $(C_t \mid \forall t = \overline{1, T^{dg}})$. This method is characteristic of the mutual arrangement of final supporting points sets (Ct) with non-empty (C) and partial (PC) crossing. Different coordinate search method (DC) is used in all kinds of mutual location of final supporting points sets (Ct) and characterized by different coordinates of the end points Gr IR positioning.

At level V, depending on the shape of crossing two methods of finding supporting points are used. They are exhaustive search (ES) and mathematical expectation (ME). The submitted concretization of using ES and ME reproduces the VI level of A_t-method. Mathematical expectation method ME is used depending on the shape of mutual arrangement of end points sets $(C_t \mid t = \overline{1, T^{dg}})$ of all working positions. The method of exhaustive search ES is used for all forms of crossings and means searching each starting point (At) with all end points (Ct) of all working positions with the subsequent determination of point pairs that have the lowest expenses of the consumed kinematic resources.

The final level VII of At-method is a union (U) of results found by different methods, and the choice of supporting points positioning Gr IR with the smallest consumed kinematic resource.

According to this method the algorithmic automated determination of CSP Gr IR trajectory space is developed. It takes into account the determination of limiting points of stationary, one-armed IR of different structural designs.