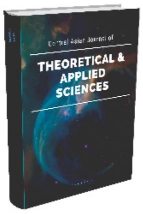

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Varieties of Industrial Robot Movement Trajectory

Butaev Tuxtasin PhD
Kokand Branch of Tashkent State Technical University Great Teacher

Siddikov Rasuljon PhD
Kokand Branch of Tashkent State Technical University Great Teacher

Rahmonov Xusanboy PhD
Kokand Branch of Tashkent State Technical University Great Teacher

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ABSTRACT:

The article shows that when designing the motion trajectory of an industrial robot (IR), attention should be paid to the following, i.e., the IR motion trajectory is divided into intermediate sections, in which sufficient conditions are set for the physical quantities representing robot motion. Since the management of the SR workforce is multi-option, there are criteria such as safety, accessibility, reliability associated with its movement. If the information about any node point of the robot is insufficient, then the detection criterion is given in order to eliminate the uncertainty.

Keywords: Industrial robot, polynom, starting point, exit point, approach point and end point, capture device

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INTRODUCTION

When operating an industrial robot (IR) along a projected motion trajectory, it is necessary to determine the robot configuration at the start and end points of the trajectory. In designing the motion trajectory of the IR in the space of generalized variables, attention should be paid to the following: In general, the trajectory of the IR is divided into intermediate sections, in which sufficient conditions are set for the physical quantities representing robot motion. For example, in the section from the exit point to the approach point, the IR velocity is at a high (maximum) level (Figure 1). If this speed is on the section from the starting point to the exit point or on the section from the approach point to the end point, then the working hand of the IR may collide with the technological barrier. The trajectory of this motion is also varied in plots. In the first plot, the distance between the starting point and the exit point is written with the fourth-order polynomial, in the second middle plot, the distance between the exit point and the point of convergence is written with the third-order polynomial, and in the second plot with the fourth-order polynomial.

METHODOLOGY

The arbitrary trajectory of the IR passes through four points: the starting point, the exit point, the approach point, and the end point. The interval of these points is divided into sections, and they are written with polynomials of the required degree. The selected polynomials must satisfy the following boundary conditions [1]:

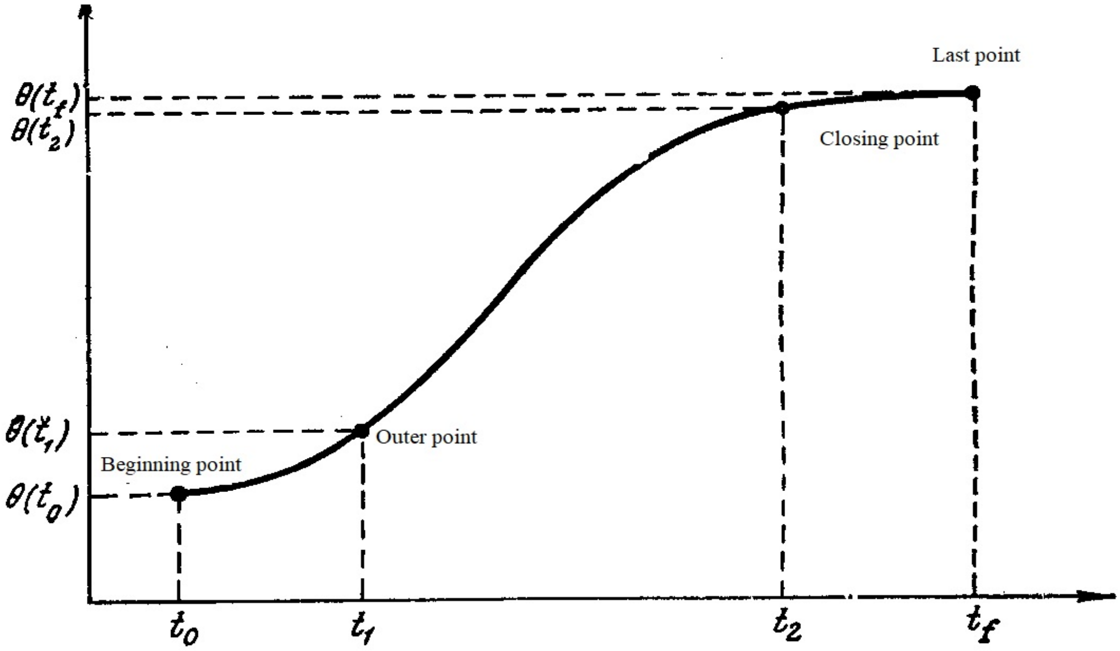

Figure 1. An overview of the arbitrary motion trajectory of the IR.

1. Starting $=\theta_0 = \theta(t_0)$ point
2. Initial speed $= v_0$(usually zero)
3. Initial acceleration $= a_0$ (usually zero).
4. continuity in $=\theta_1 = \theta(t_1)$ point.
5. t_1 continuity in $(\theta(t_1^-) = \theta(t_1^+))$. time
6. t_1 Continuity in speed over time $(v(t_1^-) = v(t_1^+))$.
7. t_1 Continuity in acceleration $(a(t_1^-) = a(t_1^+))$.
8. $\theta_2 = \theta(t_2)$ position at point.
9. t_2 continuity in $(\theta(t_2^-) = \theta(t_2^+))$.
10. t_2 continuity in speed over time $(v(t_2^-) = v(t_2^+))$.
11. t_2 continuity in acceleration $(a(t_2^-) = a(t_2^+))$.
12. The latter case $=\theta_f = \theta(t_f)$.

13. Last speed value $= v_f$ (usually zero).

14. The value of the final acceleration $= a_f$ (usually zero).

IR is one of the main directions of scientific research work on robots, designing its auxiliary, basic or universal optimal motion in the nature of participation in the technological process. The design of IR movement can be divided into two. The first is to design the motion of the IR at the start and end , the more the last, i.e. the grasping device, and the second is to design the motion by studying the properties of each node point of it. There is a single traction trajectory in the fixed position of time [2].

$$N_{\Pi C}=\prod_{j=1}^{N} n_j C_n^k (N-k+1)!,2\le k\le N-1$$

But the first issue does not participate in the IR movement as complete information. Therefore, in almost all cases, the second issue is addressed in order to know the details of the motion of each node point. Since the management of the IR workforce is multi-option, there are criteria such as safety, accessibility, reliability associated with its movement. If the information about any node point of the robot is not enough, then the detection criterion is added in order to eliminate the uncertainty [1]. This criterion is useful for IRs operating in sliding mode. The reason is that in the sliding mode, the structures of the IRs are variable. Safety Criteria - The IR must ensure safety in movement from the starting point to the end point. The criterion of suitability is that given that the IR is a complex mechanism in terms of kinematic appearance and the machine has a different size of the occupancy zone, the IR gripping device must ensure that it does not hit the part when removing the part from the collector. Criteria of reliability - The IR gripping device must be able to act reliably against external and internal forces acting on the distance from the collector to the part to be removed and placed on the machine. The first and second criteria address the problems associated with by passing the IR worker's hand when it encounters technological obstacles. That is, these two criteria ensure the organization of free space in the IR worker's hand movement. However, the trajectory of the IR in this free space is not unique, but in a fixed state of time their number is as follows [2]

$$N_{\Pi C} = \prod_{i=1}^{N} n_i (N! + \sum_{k=2}^{N} C_n^k (N-k+1))!$$

Although IR has many trajectories, not all of them are effective in terms of time-absorption and technological barrier detection, i.e., safety. Therefore, in finding such an effective trajectory, the movement of the IR in the field of technological application or in the coordinate system, and so on. It is necessary to classify them according to their characteristics. This is because it is very difficult to find an effective trajectory for all types of robots.

MAIN PART

Before designing the SR movement, an optimal structure must be constructed relative to the relative position of the module components. The SR must then create such an efficient trajectory that, firstly, it spends less time in the production process or operation without violating the norms of placement of other components of the module in the production area, and secondly, uses the production area to a minimum.

Since the construction of an optimal structure of the TM is a matter of structural optimization, we assume that such a necessary structure has been built, and proceed to the solution of the second problem. The second issue is related to the kinematics of the SR, in which forces and moments are not involved, but mainly the velocities of the links and their corresponding displacements.

In practice, during the execution of SR technological operation or process, such a technological situation is necessary that in order to meet the above-mentioned criteria, the movement of the links has to be performed in series, not in parallel in some cases. In [2] the following combinations of link movements and corresponding velocities are given:

$(v_1, \quad v_2,..., v_n)$ - - fixed speed of serially moving links;

$(\overline{v_1, v_2,..., v_n}) -$ fixed speed of parallel moving links;

$(s_1, \quad s_2,..., s_n)$ - the distance between the projections of the displacement of successive adjacent links relative to the IR-based coordinate system;

the distance between the projections of the parallel moving adjacent links relative to the IR-based coordinate system.

Suppose that the displacement of the coordinates $s_1, s_2 -$ is a fixed velocity value corresponding to the parallelism of the coordinate displacement, v_1, v_2 $(\overline{s_3, s_4,..., s_{k+3}}) -$ and $(\overline{s_3, s_4,..., s_{k+3}}) -$ the velocity value corresponding to the sequence of the remaining $(s_{k+4}, s_{k+5},..., s_n) -$ coordinate displacements, $(v_{k+4}, v_{k+5},..., v_n)$ denoting the velocity value corresponding their sequential motion.

Through this complex combination of IR link shifts, the following expression can be written to move a detail (kinematic detail is considered as a material point) from one state to another:

$$\langle s_1, s_2, (\overline{s_3, s_4,..., s_{k+3}}), s_{k+4},..., s_n \rangle$$

$$\langle v_1, v_2, (\overline{v_3, v_4,..., v_{k+3}}), v_{k+4},..., v_n \rangle$$

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