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Coordinate Transformation in the Methods of Calibration of Industrial Robots

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Commentary

A set of measures for equipping a robot with a new tool involves performing a calibration procedure for this tool before it is used in the work. This is necessary for the correct performance of the industrial robot tool movement in the robot's workspace monitored by control system. To do this, mathematical models describing the transformations of coordinates in this robot model must be supplemented by a mathematical model formed for the installed instrument. Mathematical models describing coordinate transformations for a tool are created by the control system automatically when the instrument calibration procedure is executed before the new tool is put into operation. The created mathematical models are stored in the permanent memory of the controller of the control system in the tool library, indicating the logical name assigned to the tool. Subsequently, when programming the motion of an industrial robot, the control system specifies the tool to be installed on the robot by assigning a special parameter to the logical name of the selected tool.

The tool calibration procedure is performed in two steps. The first step is to determine the point center of the tool (TCP - Tool Center Point). The second step involves actions to determine the orientation of a rectangular coordinate system associated with the tool, the beginning of which is placed in TCP. This article is devoted to the study of the second final stage of instrument calibration, namely the development of mathematical models of control systems for industrial robots designed to calibrate a new instrument.

Industrial robots are multistage mechanical systems with a sequential structure. Their links with each other form kinematic pairs of the fifth class and are modeled by solid bodies. Such multi-link mechanical systems are called manipulation systems. An example of a manipulative system of the KUKA KR6 AGILUS industrial robot, having six degrees of mobility, is presented in Figure 1. The figure shows the contours of the links of the robot and the hinges, indicating the axes of the relative rotation of the links connected by them. The tool can be rigidly attached to the last link of the industrial robot manipulation system. For this purpose, the connecting flange is provided in the design of the last link. In Figure 1, the connecting flange is depicted in the form of a disk, inside of which there is a hinge with the rotation axis perpendicular to the plane of the disk.

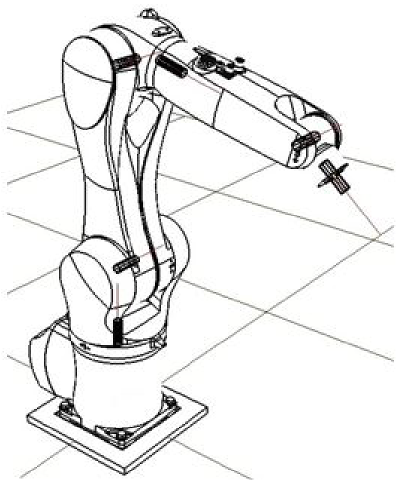

Figure 1: Manipulation system of industrial robot KUKA KR6 AGILUS.

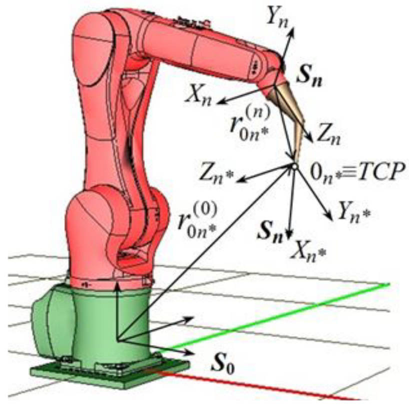

Figure 2: Coordinate systems S_0≡*WORLD*, S_n≡*FLANGE*, S_{n^*}≡*TOOL* and point 0_{n^*}≡*TCP.*

To describe the relative motion of the manipulation system links, mathematical models are used to ensure the transformation of coordinates between coordinate systems associated with each link and the coordinate system associated with a fixed base.

In industrial robot control systems, the fixed coordinate system S_0 is called WORLD and is named the global coordinate system. The origin of the S_n coordinate system connected to the finite element is placed in the center of the mounting flange, and the Z_n axis of this coordinate system is directed perpendicular to the plane of the flange along the axis of its rotation. The S_n coordinate system is called FLANGE. The point of the tool center is denoted by 0_{n^*} and referred to as TCP. The coordinate system Sn^*= TOOL with the beginning at the 0_{n^*} ≡ *TCP* point, is associated with the tool attached to the flange (Figure 2).

The obtained mathematical models can be used in industrial robot control systems. Issues similar to this topic are considered [1-5].

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