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Efficient Computational Inverse Method for Positioning Accuracy Estimation of Industrial Robot Under Stochastic Uncertainties

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ABSTRACT

The small uncertainties of geometric parameters of industrial robot, which are caused by links manufacturing and service wear errors, can deteriorate the positioning accuracy of end-effector through multi-level propagation and is difficult to be measured and compensated by high-precision instruments. Hence, an efficient inverse identification method of parameter uncertainty based on global sensitivity analysis and optimal measurement point selection is proposed. In order to ensure the universality of identification results in calibration and control works, the standard Denavit-Hartenberg (D-H) method is employed to establish the kinematic model of series 6 degrees of freedom (DOF) robots. Considering the stochastic error between nominal structural parameters and actual ones, the mean and variance indexes are used to describe the uncertainty of 24 D-H parameter errors and are introduced to the kinematic model, and then the model is linearized to obtain the uncertain indexes identification coefficient matrix. It is not feasible to direct identification the uncertainty of high dimensional parameters from arbitrary position. To solve this problem, Sobol'-based sensitivity method is developed to rank the contribution of DH parameters to positioning accuracy so that reduce redundant parameters. Simultaneously, an orthogonal matching tracking method is designed to select the optimal measurement points to reduce the ill-condition of the matrix. Then, the updated identification equation is solved by inverting. Finally, the cases on 6 DOF robot indicate the effectiveness of the proposed inverse identification method.

KEYWORDS

Industrial robot; positioning accuracy; uncertain inverse analysis; sensitivity analysis

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