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Reliability-Based Motion Stability Analysis of Industrial Robots for Future Factories

Shuoshuo Shen[1,2], Jin Cheng[1,2,*], Zhenyu Liu[2] and Jianrong Tan[1,2]

[1]State Key Laboratory of Fluid Power and Mechatronic Systems, Zhejiang University, Hangzhou, 310058, China

[2]Engineering Research Center for Design Engineering and Digital Twin of Zhejiang Province, Zhejiang University, Hangzhou, 310058, China

[*]Corresponding Author: Jin Cheng. Email: jcheng@zju.edu.cn

ABSTRACT

Motion stability assessment of industrial robots subject to complex dynamic properties and multi-source uncertainties in open environments registers an important yet challenging task [1–5]. To tackle this task, this study proposes a new reliability-based motion stability analysis method for industrial robots, which incorporates the moment-based method and Bayesian inference-guided probabilistic model updating strategy. To start with, the comprehensive motion system model of industrial robots is established by integrating the control, drive, and multi-body motion models. The reliability-based stability model of industrial robots is presented considering the uncertainty of parameters. Subsequently, the fractional exponential moments are adopted to achieve uncertainty quantification for motion performance. A versatile mixture probability distribution model is introduced to evaluate the reliability and stability, enabling more precise modeling of asymmetric distributions. To capture sufficiently uncertainty information of the robotic system performance, two solution strategies for probabilistic model parameters are developed by incorporating the direct and sequential Bayesian updating methods. With fractional exponential moments, the proposed probability model is calibrated to reconstruct the probability distribution and calculate the failure probability for industrial robots. The effectiveness of the proposed method is validated by numerical examples, wherein Monte Carlo simulation and other prevailing methods are performed for comparison. The case studies indicate that the proposed method is viable to assess the reliability and motion stability of robots with satisfactory computational accuracy and efficiency.

KEYWORDS

Reliability analysis; stability analysis; Bayesian inference; moment-based method; industrial robots

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