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论文与报告

基于数据挖掘与系统理论建立摩擦模糊模型与控制补偿

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摘要
建立机械摩擦力模型及其相应的控制补偿策略一直是人们所关注的问题. 由于摩擦力所固有的非线性及不确定特征, 用传统的数学建模与控制补偿方法难以达到满意的系统性能要求. 本文采用模糊建模技术逼近摩擦动力系统并将辨识结果用在前馈补偿控制器设计中. 模糊建模过程由以下3个部分组成: 首先采用数据挖掘技术辨识出模糊系统的模糊规则库, 然后利用该规则库建立模糊系统的静态模型, 最后以李雅普诺夫稳定性理论为基础进一步辨识出模糊系统的动态模型. 在控制器设计方面, 采用了自适应模糊系统前馈补偿的比例微分(Proportional-derivative, PD)算法. 运用李雅普诺夫稳定性分析证明了闭环系统跟踪误差的有界性. 数值仿真结果表明了该方法的有效性和实用性.

关键词 摩擦动力 模糊模型 数据挖掘 李雅普诺夫稳定性 前馈控制补偿
分类号

Data Mining and Systems Theory Based Fuzzy Modeling and Control Compensation for Friction

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Abstract
Modeling and control compensation of friction force has been a challenging task in mechanical engineering. The traditional way, such as mathematical modeling approache, was found quite difficult to achieve satisfactory performances due to some immanent nonlinearity and uncertainties of the system. This paper aimed to develop fuzzy modeling techniques to characterize the friction dynamics, which can then be employed in a feed-forward compensation controller design. The proposed fuzzy modeling approach is three fold: extraction of fuzzy rules using data mining techniques, setup of static model based on the fuzzy rules, and fuzzy identification of dynamic model according to Lyapunov theory. An adaptive version of the fuzzy feed-forward compensation proportional-derivative (PD) control law was employed in the control system. A theoretical result on estimates of error bounds for closed-loop systems was established by the well-known Lyapunov stability theory. An numerical example was analysed in details and simulation results demonstrated its the usefulness and effectiveness.

Key words Friction dynamics fuzzy model data mining Lyapunov stability feed-forward control compensation

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