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基于ODE参数辨识的液压伺服系统灰箱建模

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Grey-box Modeling of Hydraulic Servo Systems Based on ODE Parameter Identification

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摘要

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摘要

针对液压伺服系统常规“白箱”建模由于参数无法精确获得导致所得模型精度不高及“黑箱”建模所得模型内部结构未知的问题,本文提出基于ODE参数辨识的液压伺服系统“灰箱”建模。首先,建立了工程上实用的系统状态空间模型,根据系统特征确定了待辨识参数,将模型辨识问题转化为常微分方程(ODE)参数辨识问题;然后,采用正弦扫频信号作为激励信号和基于带边界约束的信赖域优化算法的初值问题方法进行参数辨识;为了和ODE参数辨识结果进行对比,本文同时采用系统的频率响应数据和最小二乘法辨识得到系统的“黑箱”传递函数模型;最后,通过大量实验验证了辨识模型的精确度。实验结果表明,本文提出的基于信赖域算法的液压伺服系统模型辨识方法可以有效处理参数的边界问题,使辨识模型既具有实际的物理意义,又与实际系统高度符合。

关键词: 液压伺服系统 灰箱建模 常微分方程 参数辨识 信赖域 边界约束

Abstract:

In view of the fact that white-box modeling cannot supply an accurate model due to the unavailability of accurate parameters and that black-box model structure is unknown, this paper tries to implement a grey-box modeling of hydraulic servo systems utilizing ODE parameter identification. A practical state space model of the system is first constructed, and parameters that need to be estimated are then defined. Parameter identification is carried out utilizing sine sweep data and the initial value problem approach (IVPA) based on trust region method (TRM) which is able to handle the bound constraints on the parameters. Black-box transfer function models are also acquired utilizing frequency response data to compare with the results of ODE parameter identification. Finally, extensive experiments are performed to testify the quality of the identified models. Experiment results show that the proposed method for identifying hydraulic servo systems based on TRM is able to handle parameter bounds effectively, which results in a model that is not only physically reasonable, but also corresponds highly with the practical system.

Keywords: hydraulic servo system grey-box modeling ordinary differential equations parameter identification trust region bound constraint

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