化工学报 2008 59 (7): 1671-1676 ISSN: 0438-1157 CN: 11-1946/TQ

过程系统工程

基于神经网络和多模型的非线性自适应PID控制及应用

刘玉平, 翟廉飞, 柴天佑

东北大学自动化研究中心

收稿日期 2008-4-15 修回日期 2008-4-20 网络版发布日期 2008-7-15 接受日期

摘要

针对一类未知的单输入单输出离散非线性系统，提出了基于神经网络和多模型的非线性自适应PID控制方法。该方法由线性自适应PID控制器、神经网络非线性自适应PID控制器以及切换机构组成。采用线性自适应PID控制器可保证闭环系统所有信号有界；采用神经网络非线性自适应PID控制器可改善系统性能；通过引入合理的切换机制，能够在保证闭环系统稳定的同时，提高系统性能。理论分析表明，该方法能够保证闭环系统所有信号有界，如果适当地选择神经网络的结构和参数，系统的跟踪误差将收敛于任意给定的紧集。将所提出的方法应用于连续搅拌反应釜，仿真结果验证了所提出方法的有效性。由于该方法基于增量式数字PID控制器，在工业过程中有着广阔的应用前景。

关键词

PID控制 自适应控制 多模型 神经网络 连续搅拌反应釜

分类号

Nonlinear adaptive PID control using neural networks and multiple models and its application

LIU Yuping,ZHAI Lianfei,CHAI Tianyou

Abstract

For a class of single-input and single-output discrete-time nonlinear systems，a nonlinear adaptive proportional-integral-differential（PID）control method was proposed by using neural networks and multiple models. Such control method was composed of a linear adaptive PID controller，a neural-based nonlinear adaptive PID controller and a switching mechanism. The linear adaptive PID controller was used to guarantee the boundedness of all signals in the closed-loop system，while the neural-based nonlinear adaptive PID controller was employed to improve the performance of the closed-loop system. By introducing a reasonable switching mechanism，the stability of the closed-loop could be guaranteed，while the control performance was improved. Theoretical analysis illustrated that the proposed control method could guarantee the boundedness of all signals in the closed-loop system，while the tracking error would convergent to any given compact set if the structure and parameters of the neural networks were properly chosen. Then the proposed control method was applied to a continuous stirred tank reactor（CSTR）. Simulation result of CSTR demonstrated the effectiveness of the proposed control method. Since the proposed control method was based on the incremental digital PID controller，it had a bright application prospect in industrial process control.

Key words

PID control adaptive control multiple models neural network continuous stirred tank reactor

DOI:

通讯作者 刘玉平 liuyupingneu@gmail.com