光学精密工程 OPTICS AND PRECISION ENGINEERING

核心期刊

主管：中国科学院

主办：中国科学院长春光学精密机械与物理研究所

中国仪器仪表学会

主编：曹健林

光学精密工程 2012, 20(3) 587-596 ISSN: 1004-924X CN: 22-1198/TH

微纳技术与精密机械

压电工作台的神经网络建模与控制

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摘要： 建立了压电工作台的神经网络在线辨识模型并设计了相应的自适应控制器以抑制压电工作台迟滞特性、蠕变特性及动态特性对其微定位精度的影响。采用双Sigmoid激活函数对神经网络激活函数进行了改进,同时分析了改进激活函数的神经网络模型与PI迟滞模型在迟滞建模上的异同。设计了基于改进激活函数的3层BP神经网络作为压电工作台的在线辨识模型,推导了网络权值、阈值及激活函数阈值修正公式。最后,基于神经网络模型设计了压电工作台的自适应控制方案,该控制方案利用另外一个神经网络来完成对PID控制器参数的自适应调整。实验结果表明:提出的神经网络在线辨识模型平均误差为0.095 μm,最大误差为0.32 μm;自适应控制方案跟踪三角波的平均误差为0.070 μm,最大误差为0.100 μm;跟踪复频波的平均误差为0.80 μm,最大误差为0.105 μm。实验数据显示压电工作台的定位精度得到了有效提高。

关键词： 压电工作台 神经网络 迟滞 自适应控制

Modeling and control of piezo-stage using neural networks

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Abstract: An online identification neural network model and an adaptive controller were designed and verified by simulations to inhibit the influence of hysteresis, creep and dynamic characteristics of a piezo-stage on the positioning accuracy. First, the double Sigmoid activation function was adopted to improve the activation functions of neural networks, and the similarities and differences between improved neural work model and PI hysteresis model were analyzed. Then, a BP neural network with three layers based on the improved activation function was designed as the online identification model of piezo-stage, and the correction formulas for the network weights, thresholds as well as the activation function thresholds were derived. Finally, the adaptive control scheme of the piezo-stage was proposed based on the online identification neural network model, which made use of another neural networks to complete the parameter adjustment of an adaptive PID controller. Experimental results show that the average error and the maximum error are 0.095 μm and 0.32 μm for the online identification neural network model, 0.070 μm and 0.100 μm for the adaptive control scheme on tracking triangle waves, and 0.080 μm and 0.105 μm for the tracking multiple frequency wave, respectively. Obtained data prove that positioning accuracy of the piezo-stage is improved effectively.

Keywords: piezo-stage neural network hysteresis adaptive control

收稿日期 2011-09-01 修回日期 2011-11-10 网络版发布日期 2012-03-22

基金项目:

国家自然科学基金资助项目(No.61174044);国家自然科学基金资助项目(No.50877046);山东省优秀中青年科学家科研奖励基金项目(No.BS2011DX037);泰安市科技发展计划项目(No.20102026)

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