

压电式快速控制反射镜的迟滞特性及线性化

袁刚^{1,2}, 张小波¹, 王代华^{1,2}, 陈敏¹

1. 重庆大学 光电技术及系统教育部重点实验室, 重庆 400044;
2. 重庆大学 光电工程学院 精密与智能实验室, 重庆 400044

Hysteresis and linearization of piezoelectric fast steering mirror

YUAN Gang^{1,2}, ZHANG Xiao-bo¹, WANG Dai-hua^{1,2}, CHEN Ming¹

1. Key Laboratory of Optoelectronic Technology and Systems of the Ministry of Education, Chongqing 400044, China;
2. Precision & Intelligence Laboratory, College of Optoelectronic Engineering, Chongqing University, Chongqing 400044, China

摘要

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全文: PDF (1502 KB) RICH HTML ^{NEW}

输出: BibTeX | EndNote (RIS)

摘要 针对压电式快速控制反射镜(Fast Steering Mirror, FSM)的迟滞问题,分析了压电式FSM的工作原理和迟滞特性,建立了基于Bouc-Wen算子的压电式FSM的数学模型及其参数辨识方法.通过Bouc-Wen算子模拟压电式FSM输出镜面偏转角度中的迟滞分量,并根据在两个相位相同的输入驱动电压信号下压电式FSM的输出镜面偏转角度曲线辨识Bouc-Wen算子的全部参数.在此基础上,提出了压电式FSM的前馈线性化方法.为了验证提出的数学模型和线性化方法的原理,建立了压电式FSM及其线性化控制器的快速原型系统和Bouc-Wen算子参数辨识实验装置.实验结果表明:本文提出的参数辨识方法能够准确辨识压电式FSM的Bouc-Wen算子参数,提出的前馈线性化方法能够将压电式FSM的输出镜面偏转角度与输入控制电压的线性度提高到2.3%,迟滞误差减小到 $\pm 0.5\%$,满足实际应用对精确控制压电式FSM的要求.

关键词 : 快速控制反射镜, 压电陶瓷叠堆执行器, 倾斜镜, 迟滞, 线性化

Abstract : For the hysteresis of a piezoelectric Fast Steering Mirror (FSM), the working principle and hysteresis properties of the piezoelectric FSM were analyzed. The Bouc-Wen hysteresis operator based mathematical model of the piezoelectric FSM and the corresponding parameter identification method were proposed. The hysteresis component of excursion angle of the piezoelectric FSM was estimated by the Bouc-Wen hysteresis operator, and parameters of Bouc-Wen hysteresis operator were identified according to the excursion angles of the piezoelectric FSM at two driven voltage waves with the same phase position. On this basis, a feedback forward linearization method for the piezoelectric FSM was proposed. In order to validate the proposed mathematical model and linearization method, the rapid prototyping system for the piezoelectric FSM and a linearization controller and an experimental set for the parameter identification of the Bouc-Wen hysteresis operator were established. The experimental results show that the proposed identification method estimates the parameters of the Bouc-Wen hysteresis operator of the piezoelectric FSM accurately and the feedback forward linearization method increases the linearity of mirror deflection angle and input control voltage of the piezoelectric FSM by 2.3% and decreases the delaying error by $\pm 0.5\%$ respectively. It satisfies the requirements of precision control of the piezoelectric FSM.

Key words : Fast Steering Mirror (FSM) Piezoelectric Ceramic Stack Actuator (PCSA) tilt mirror hysteresis linearization

收稿日期: 2015-01-23

中图分类号: TN384

TH703

基金资助:中央高校基本科研业务费资助项目(No.CDJZR12120005)

作者简介: 袁刚(1982-),男,湖北麻城人,博士,讲师,2003年、2006年、2010年于重庆大学分别获得学士、硕士、博士学位,主要从事智能结构与系统、传感器技术和振动能量收集等方面的研究.E-mail:cquyuan@cqu.edu.cn 张小波(1990-),女,四川崇州人,2013年于合肥工业大学获得学士学位,主要从事压电执行器与系统的研究.E-mail:20130802050@cqu.edu.cn

引用本文:

袁刚, 张小波, 王代华, 陈敏. 压电式快速控制反射镜的迟滞特性及线性化[J]. 光学精密工程, 2015, 23(6): 1650-1656. YUAN Gang, ZHANG Xiao-bo, WANG Dai-hua, CHEN Ming. Hysteresis and linearization of piezoelectric fast steering mirror. Editorial Office of Optics and Precision Engineering, 2015, 23(6): 1650-1656.

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地址:长春市东南湖大路3888号 邮编:130033 E-mail: gxjmgc@sina.com

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