光学 精密工程
OPTICS AND PRECISION ENGINEERING
核心期刊
主管：中国科学
主办：中国科学
中国仪器
主编：曹健林

光学精密工程 2012, 20(3) 468-476 ISSN: 1004-924X CN: 22-1198/TH

现代应用光学

双Mach-Zehnder光纤干涉传感系统中的偏振衰落控制

曾周末, 张溪默, 封皓, 靳世久, 安阳

天津大学 精密测试技术及仪器国家重点实验室, 天津 300072

摘要： 针对偏振衰落现象导致信号关联的二义性使分布式双Mach-Zehnder光纤干涉传感系统难以实现高精度定位的问题,提出了一种控制振衰落的方法来保持系统检测信号的稳定性。利用系统的偏振模型分析了偏振衰落的来源,指出传感光纤偏振特性的不一致使系统检测信号对入偏振态敏感是造成信号相关性恶化的根本原因,据此提出控制输入偏振态、搜索偏振态工作点的抗偏振衰落思想。在此基础上通过分析输入振态的两个参量对信号相关系数的作用进一步明确了偏振控制对算法的要求,并利用模拟退火算法进行了验证。现场实验表明,该算法可快速搜偏振态工作点,持续稳定系统检测信号的相关性;结果证实了提出的偏振衰落控制方法可行且有效。

关键词： 相干光学 Mach-Zehnder干涉仪 干涉传感 偏振衰落 偏振控制 相关系数 模拟退火算法

Control of polarization fading for dual Mach-Zehnder fiber interferometric sensing system

ZENG Zhou-mo, ZHANG Xi-mo, FENG Hao, JIN Shi-jiu, AN Yang

State Key Laboratory of Precision Measuring Technology and Instruments, Tianjin University, Tianjin 300072, China

Abstract: In a dual Mach-Zehnder fiber interferometric sensing system, the high locating accuracy is hardly obtained due to the discrepancy of two detection signals resulting from polarization fading. To keep the stability of the detecti signals, a method to control the polarization fading was proposed in this paper. A optical polarization model was established to analyze the origin of polarization fading in the system. It points out that the basic reason for the discrepancy of the detection signal correlation is from that the inconsistency of the polarization characteristics betwe two sensing fibers results in the effect of the input polarization on detection signals. Based on the analysis, the solutions of controlling the input polarization and searching for the working points of polarization state were put forward to eliminate the polarization fading. Furthermore, the requirements of polarization control were further determined by analyzing the relation between signal correlation coefficients and two parameters of input polarizatior and simulated annealing was applied to the verification of this theory. Field test results show that the algorithm can make a fast search for the working points of polarization state, and can maintain a steady signal correlation. It is proved that the polarization fading control method is feasible and effective.

Keywords: coherence optics Mach-Zehnder fiber interferometer interferometric sensing polarization fading polarization control correlation coefficient simulated annealing

收稿日期 2011-08-26 修回日期 2011-10-27 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.60974110);国家教育部博士点基金资助项目(No.200800560020)

通讯作者: 张溪默 (1986-),男,湖北当阳人,硕士研究生,主要从事偏振控制、自动测控系统等方面的研究。E-mail: zxm2514@163.com

作者简介:

作者Email:

参考文献：

[1] 周琰,靳世久,曾周末,等. 分布式光纤管道安全检测定位技术研究 [J].光电子·激光,2008,19(7):922-924. ZHOU Y,JIN SH J,ZENG Z M, *et al.*. Study on the distributed optical fiber sensing technology for pipeline safety detection and location [J].*Journa of Optoelectronics · Laser*, 2008, 19(7):922-924.(in Chinese) [2] 封皓,靳世久,曾周末,等. 基于琼斯矩阵建模的管道泄漏检测及预警系统的定位误差分析 [J].光学学报,2009,29(3):723-727. FENG H, JIN SH J,ZENG ZH M, *et al.*. Locating error analysis in pipeline leakage detection and prewarning system based on modeling using Jones matrix[J].*Acta Optica Sinica*, 2009,2 (3):723-727.(in Chinese) [3] FENG H, ZHU L, JIN S J, *et al.*. Modeling of pipeline leakage detection and prewarning system for locating error analysis based on Jones matrix[J].*Journal of the Japan Petroleum Institute*, 2009, 52(3):114-119. [4] 谭靖,陈伟民,付玉梅. 琼斯矩阵在分布式光纤传感器偏振态分析中的应用 [J].光电工程,2007,34(5):120-125. TAN J, CHEN W M, FU Y M.Application of Jones matrix in the research of polarization effects of the distributed optic fiber sensor[J]. *Opt electronics Eng.*, 2007, 34(5):120-125. (in Chinese) [5] 孙刚,金世龙. 双折射晶体琼斯矩阵分析 [J].应用光学,2005,26(4):17-21 SUN G, JIN SH L. Analyses of Jones matrix of birefringent grystals[J]. *Journal of Applied Optics*, 2005, 26(4):17-21. (in Chinese) [6] 张靖华. 双折射光纤琼斯矩阵的一般表达式及反射传输特性 [J].光子学报,1997,26(6):527-531. ZHANG J H. General expression of Jones matrix in birefriengent fibers and reflective transmission characteristics[J]. *Acta Photonica Sinica*, 1997, 26(6):527-531. (in Chinese) [7] 廖延彪.偏振光学[M].北京:科学出版社,2003. LIAO Y B.*Polarization Optics* [M].Beijing:Science Press, 2003.(in Chinese) [8] 陈玄令,沈国荣. 复合函数奇偶性的判断方法 [J].渤海大学学报(自然科学版),2008,29(2):158-160. CHEN X L, SHEN G R. Method to judge whether composite functions are even or odd [J]. *Journal of Bohai University(Natural Science Edition)*, 2008,29(2):158-160. (in Chinese) [9] 曾喜萍. 复合函数周期性 [J].广西大学学报(自然科学版),2004,29(3):190-192. ZENG X P. The periodicity of composite functions[J]. *Journal of Guangxi Universi (Natural Science Edition),* 2004,29(3):190-192.(in Chinese) [10] 康立山,谢云,尤矢勇,等. 非数值并行算法(第一册)模拟退火算法 [M].北京:科学出版社,1998. KANG L SH, XIE Y, YOU SH Y, *et al.*. *Non-numerical Parallel Algorithms(The first volume)Simulate*

Annealing[M]. Beijing: Science Press, 1998. (in Chinese) [11] 黄平. 最优化理论与方法 [M].北京:清华大学出版社,2009. HUANG P.*Optimal Theories and Methods*[M]. Beijing:Tsinghua University Press, 2009.(in Chinese) [12] 高贯斌,王文,林铿,等. 应用改模拟退火算法实现关节臂式坐标测量机的参数辨识 [J].光学 精密工程,2009,17(10):2499-2505. GAO G B, WANG W, LIN K,*et al.*. Parameter identification based on modified annealing algorithm for articulated arm CMMs[J].*Opt. Precision Eng.*, 2009, 17(10):2499-2505.(in Chinese) [13] 刘勇,康立山,陈毓屏,等. 非数值并行算法(第二册)遗传算法 [M].北京:科学出版社,2003. LIU Y, KANG L SH, CHEN Y P, *et al.*. *Non-numerical Parallel Algorithms(The Second Volume)Genetic Annealing*[M]. Beijing: Science Press, 1998. (in Chinese)

本刊中的类似文章

1. 吴新杰 黄国兴 王静文.压缩感知理论在ECT流型辨识中的应用[J]. 光学精密工程, 2013,21(4): 1062-1068
2. 郭春 李斌成.用模拟退火法确定MgF_2薄膜折射率和厚度[J]. 光学精密工程, 2013,21(4): 858-863
3. 吴新杰, 黄国兴, 王静文.粒子滤波算法在ECT图像重建中的应用[J]. 光学精密工程, 2012,(8): 1824-1830
4. 王志斌, 史国华, 何益, 丁志华, 张雨东.光学相干层析技术在光学表面间距测量中的应用[J]. 光学精密工程, 2012,20(7): 1469-1474
5. 潘绍松, 左洪福.工业增强现实中的相机跟踪[J]. 光学精密工程, 2011,19(6): 1353-1359
6. 任恩恩, 鲁 彦, 鲁怀伟, 罗冠炜.全光纤MZI型三信道波长交错滤波器的改进[J]. 光学精密工程, 2010,18(7): 1483-1490
7. 高贯斌,王文,林铿,陈子辰.基于改进模拟退火算法的关节臂式坐标测量机参数辨识[J]. 光学精密工程, 2009,17(10): 2499-2505
8. 李鸿炜.微型胃肠道介入式诊疗装置的便携定位系统设计[J]. 光学精密工程, 2008,16(3): 492-499
9. 鲁怀伟[1,2];张玉娥[3];罗冠炜[1].基于2×2和3×3耦合器的级联 马赫-曾德干涉仪型波长交错滤波器[J]. 光学精密工程, 2007,15(7): 1021-1025
10. 周 曲;颜国正;王文兴.相关系数分析在模糊图像参数识别中的应用[J]. 光学精密工程, 2007,15(6): 988-995
11. 鲁怀伟[1,2];章宝歌[1];李敏芝[2];罗冠炜[2].基于双耦合器的平坦型全光纤波长交错滤波器[J]. 光学精密工程, 2006,14(2): 145-150
12. 吴新杰 黄国兴 王静文.粒子滤波算法在ECT图像重建中的应用[J]. 光学精密工程, ,(): 0-0
13. 曾周末 张溪默 封皓 靳世久 安阳.双Mach-Zehnder光纤干涉传感系统中的偏振衰落控制[J]. 光学精密工程, ,(): 0-0