本期目录 ｜ 下期目录 ｜ 过刊浏览 ｜ 高级检索　　　　　　　　　　　[打印本页] [关闭]

现代应用光学

光学元件表面的数字全息在线检测

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摘要： 针对光学元件表面质量在线检测的特点,设计了基于数字全息的三维再现检测系统。该系统采用离轴光路,避开了被测元件的光轴,在数字全息再现过程中应用倾斜相差补偿技术去除了由于离轴检测引入的倾斜相位畸变。在检测过程中,利用围绕光轴旋转被测元件的方法来改变入射照明光方向矢量和相应的观察方向,实现了多照明矢量合成孔径技术的应用,扩展了系统的检测距离,提高了系统分辨率。同时,多照明角度下检测数据的叠加,还有效地抑制了检测过程中出现的散斑噪声对结果准确度的影响。通过对分辨率板、高精度玻璃反射镜的检测实验,验证了该系统在光学元件表面检测中的作用。当记录距离为40 cm时,其分辨率能够达到10 μm,满足光学元件表面检测的需要。

关键词： 数字全息   光学元件   离轴检测   相位补偿   合成孔径

Digital holographic on-line detection of optic component surface

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Abstract: An on-line 3D detection system for optic component surface measurement was designed based on digital holography. An off-axis structure was chosen to evade the optical axis of a test object and the tilt phase compensation was used to eliminate the tilted phase distortion caused by an off-axis optic path. In this system, the illuminating angle and view direction could be changed by rotating the object around the optical axis, by which the recording distance was increased and the resolution was improved using synthetic aperture technique. Meanwhile, the superposition of reconstruction images could decrease the effect of speckle noise on the reconstructed distribution. The proposed method is experimentally validated by a resolution test target and an optic mirror, and it shows that the 2D resolution of the system has been 10 μm at a recording distance of 40 cm and the system noise also be suppressed effectively.

Keywords: digital holography   optic component   off-axis detection   phase compensation   synthetic aperture

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参考文献:

[1] 解亚平,孙志红,成泽,等. 光学元件损伤在线检测中的图像处理[J]. 强激光与粒子束,2006,18(7):1085-1089. XIE Y P, SUN ZH H, CHENG Z, *et al.*. Image processing in online inspection of damage in optics [J]. *High Power Laser and Particle Beams, 2006,18(7):*1085-1089.(in Chinese)

[2] 杨李茗,叶海仙. 大口径大曲率半径光学元件的高精度检测[J]. 光学 精密工程,2011,19(6):1207-1212. YANG L M, YE H X. High-precision metrology for optical components with large-apertures and large radii of curvature[J]. *Opt. Precision Eng.*, 2011,19(6):1207-1212.(in Chinese)

[3] THOMPSON C E, KNOPP C F. Optics damage inspection for the NIF . *Third International Conference on Solid State Lasers for Application to Inertial Confinement Fusion, Monterey, USA: SPIE, 1999:943-954.*

[4] RAINER F. Mapping and inspection of damage and artifacts in large-scale optics . *Laser-Induced Damage in Optical Materials, Boulder, USA: SPIE,* 998:272-281.

[5] 任冰强,黄惠杰,张维新,等. 光学元件损伤在线检测装置及实验研究[J]. 强激光与粒子束,2004,16(4):465-468. REN B Q, HUANG H J, ZHANG W X, *et al.*. Online inspection apparatus and experiments on optics damage[J]. *High Power Laser and Particle Beams, 2004,*16(4):465-468. (in Chinese)

[6] GOODMAN J W, LAWRENCE R W. Digital image formation from electronically detected holograms[J]. *Applied Physics Letters, 1967,11(3):77-79.*

[7] SCHNARS U, J PTNER W. Direct recording of holograms by a CCD target and numerical reconstruction[J]. *Applied Optics, 1994,33(2):179-181.*

[8] NICOLAS P, CHANDRA S S, JONAS K, *et al.*. Suppression of the zero-order term in off-axis digital holography through nonlinear filtering[J]. *Applied Optics,* 2009,48(34):H186-H189.

[9] DI J L, ZHAO J L, SUN W W, *et al.*. Phase aberration compensation of digital holographic microscopy based on least squares surface fitting[J]. *Optics Communications,2009,282(19):3873-3877.*

[10] SHEN B CH, CHEN C H. Application of autofocus algorithms in holographic reconstruction . *Remote Sensing and GIS Data Processing and Other Applications, Yichang, P.R. China: SPIE, 2009:74984G1-6.*

[11] 朱越,刘文耀,刘方超,等. 用数字全息术检测轮胎气泡缺陷[J]. 光学 精密工程,2009,17(5):1099-1104. ZHU Y, LIU W, LIU F CH, *et al.*. Inspection of air bubble defect in tires by digital holography[J]. *Opt. Precision Eng.*, 2009,17(5):1099-1104. (in Chinese)

[12] 周文静,彭娇,于瀛洁. 基于数字全息技术的变形测量[J]. 光学 精密工程,2005,13(增):46-51. ZHOU W J, PENG J, YU Y J.

Deformation measurement via digital holography[J]. *Opt. Precision Eng.*, 2005, 13(Supp.):46-51.(in Chinese)

[13] 黎发志,罗霄,赵晶丽,等. 离轴非球面的计算全息图高精度检测技术[J]. 光学 精密工程,2011,19(4):709-716. LI F ZI, LUO X, ZHAO J L, *et al.*. Test of off-axis aspheric surfaces with CGH[J]. *Opt. Precision Eng.*, 2011, 19(4):709-716. (in Chinese)

[14] GUO CH SH, ZHANG L, RONG ZH Y, *et al.*. Effect of the fill factor of CCD pixels on digital holograms: comment on the papers "frequency analysis of digital holography" and "frequency analysis of digital holography with reconstruction by convolution"[J]. *Optical Engineering*, 2003,42(9):2768-2771.

[15] XIAO W, ZHANG J, RONG L, *et al.*. Improvement of speckle noise suppression in digital holography by rotating linear polarization state[J]. *Chinese Optics Letters, 2011,9(6):060901-1-3.*

[16] ZHANG F C, ICHIROU Y. Algorithm for reconstruction of digital holograms with adjustable magnification[J]. *Optics Letters, 2004,29(14):1668-1670.*

[17] WANG F J, XIAO W, PAN F, *et al.*. Curvature measurement of optical surface using digital holography[J]. *Optics and Lasers in Engineering, 2011,49(7):903-906.*

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12．王忠生, 张学军.空间合成孔径成像光学系统的光瞳对称性[J]. 光学精密工程, 2011,19(9): 1999-2005

13．来志, 曾晓东, 冯喆君, 曹长庆.精密控制谐振腔获得合成孔径激光雷达信号的方法[J]. 光学精密工程, 2011,19(7): 1531-1537

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