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用于子孔径拼接干涉系统的机械误差补偿算法

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Mechanical error compensation algorithm for subaperture stitching interferometry

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摘要 针对拼接干涉检测系统机械定位精度引起的各子孔径间的相对定位误差, 提出了含定位误差补偿项的全局最优化拼接算法。介绍了该算法原理, 从理论上分析了该算法拟合出的平移和旋转定位系数的精度。结合MetroPro和Matlab软件仿真模拟实验, 分析了机械定位误差对拼接检测精度的影响。实验表明:拟合出的平移定位系数精度高于旋转定位系数精度, 与理论分析一致;相对于一般算法, 该算法对机械误差有较强的免疫力。在搭建的拼接检测装置上检测了口径为150 mm的平面镜, 结果显示:拼接结果与干涉仪直接检测的全口径相位残差的分布峰谷值(PV)为0.015 30λ, 均方根值(RMS)为 0.001 570λ, 得到的结果十分接近, 验证了该算法稳定可靠, 能够合理有效地补偿机械精度引起的子孔径定位误差。

关键词 : 拼接干涉检测, 子孔径拼接, 机械定位误差, 补偿算法, 大口径平面镜

Abstract : An error compensation algorithm was proposed by introducing a position correction compensator into general stitching algorithm to reduce the relative location errors between subapertures due to poor positioning accuracy in a subaperture stitching interferometry. The working principle of the algorithm was introduced and the accuracy of the fitted translation and rotation coefficients was analyzed in theory. Then a simulation experiment by using MetroPro software and Matlab software was implemented, and the influence of positioning accuracy on the stitching results was analyzed. The simulation result shows that the accuracy of rotation coefficient is less than that of the translation coefficient and is consistent with the theoretical analysis. Moreover, the algorithm is more robust than the general stitching algorithms. For the purpose of experimental verifying mechanical error compensation algorithm, a Φ150 mm flat mirror was tested by a subaperture stitching interferometer and a full aperture interferometer. The test results indicate that the peak-to-valley(PV) and root-mean-square(RMS) of the phase distribution residue are 0.015 30λ and 0.001 570λ, respectively as compared with the stitching results from the directly measured full aperture, which means that the optimal algorithm is stable and reliable and effectively compensates positioning system errors.

Key words : stitching interferometry subaperture stitching positioning system error compensation algorithm large aperture flat mirror

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