

基于狭缝光阑的剪切散斑干涉动态测量

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Shearing speckle interferometry based on slit aperture for dynamic measurement

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摘要

图/表

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摘要 为了精确、实时地测量物体表面的动态形变,提出了基于狭缝光阑的空间载波剪切散斑干涉系统。该系统通过倾斜迈克尔逊干涉仪的一个平面镜来产生剪切量和载波频率,实现空间频谱的移动;采用一个可调节的狭缝光阑控制散斑大小和空间频谱宽度。基于傅里叶变换与反变换在空间频率域上提取所需的频谱并计算相位图,最后通过一幅干涉条纹图得到相位分布信息。采用该系统对一个中心加载、四周固支的薄铝板进行了动态测量,分析了光学系统参数对测量结果的影响。结果表明,采用像素尺寸为 $4.65\ \mu\text{m}\times 4.65\ \mu\text{m}$ 的高分辨率相机,焦距为8 mm的成像镜头,设置剪切量为25 mm,狭缝光阑X方向的尺寸为1 mm时,可得到高质量的剪切散斑相位图。该方法可以在25 frame/s的采集速度下,以 43.6° 的视场角实现动态形变的测量,可测形变峰值为 $0.5\sim 30\ \mu\text{m}$ 。

关键词 : 剪切散斑干涉术, 空间载波相移, 傅里叶变换法, 迈克尔逊干涉仪, 狭缝光阑, 动态形变

Abstract : To measure the dynamic deformation of an object surface in real time accurately, this paper proposes a spatial carrier phase-shifting shearing speckle system based on a slit aperture. A Michelson interferometer was used to generate a shearing distance and a spatial frequency shift by tilting a small angle in one of the two mirrors. A slit aperture was used to control the speckle size and the spatial spectral width. The Fourier transform and inverse transform were applied to accurate calculation of the phase and to obtain the phase distribution by using only a single image. Finally, the shearing speckle system was used to measure the dynamic deformation of a circumferentially fixed thin aluminum plate with a point load at the center. The effects of optical system parameters on the measuring results were analyzed. The experimental results show that when the shearing distance is 25 mm and the slit aperture size in X direction is 1 mm, it is possible to obtain a better phase-map quality by using a higher spatial frequency CCD camera with a pixel size of $4.65\ \mu\text{m}\times 4.65\ \mu\text{m}$ and an image lens with a focus length of 8 mm. It demonstrates that the shearing speckle system obtains the information of deformation in real time under a capturing rate of 25 frame/s and an angle of view field 43.6° , and the measurable range of displacement peak value is from $0.5\ \mu\text{m}$ to $30\ \mu\text{m}$.

Key words : shearing speckle interferometry spatial carrier phase-shifting Fourier Transform(FT) method Michelson interferometer slit aperture dynamic deformation

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