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A SELECTIVE PHASE FILTER TECHNIQUE BASED ON SPECKLE DECORRELATION

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ABSTRACT

A new phase filter technique based on the speckle decorrelation analysis is proposed on this paper to remove the noise from the phase maps. The phase maps are extracted from speckle interferometry static measurements using the four phase shifted intensities, with the constant phase step of $\pi/2$. The speckle descorrelation points are then selected based on the average phase step of the reference and deformation states phase maps. The recursive average phase filter technique is applied to the phase maps and only the speckle decorrelation points are updated in each iteration, preserving the correct phase information. The results of the present method are compared with the well-known phase filters. It was found that the proposed method presents higher performance, particularly when dealing with phase maps which have low signal-to-noise ratio.

Keywords: phase filter, speckle decorrelation, phase-shifting, speckle interferometry.

INTRODUCTION

The speckle interferometry techniques, such as electronic speckle pattern interferometry (ESPI) and speckle shearography, allow full-field, non-contact and high sensitivity measurements of structures undergoing static or dynamic deformations, (Kreis, 2005; Steinchen, 2003). These measurements are based on the phase correlation between the reference and deformation states phase maps. For the static measurements, the interference phase maps are obtained using the phase shifting technique, where, normally, four-frame intensities are used with constant phase step of $\pi/2$, (Kreis, 2005). However, the quality of results using these techniques strongly depends on the alignment of the optical interferometer and the speckle decorrelation level in the measurements. This last component is associated to the errors produced during digitalization of the interference intensity, like background light fluctuations and electronic noise in the photodetectors, phase shifting process, environments distortions, like vibrations, acoustic noise, and air turbulence, and partial or total speckle decorrelation produced for the large deformation and rigid body motions. In all of the cases, the speckle decorrelation level can be evaluated based on computation of the average phase step of the phase maps.

This paper presents a new phase filter technique based on average phase step information for selectively removing the phase noise, allowing the preservation of the original phase information. The average phase step is computed for reference and deformation states phase maps. The phase noise points are selected based on threshold level of the correlation between the average phase steps of the two states. A recursive average phase filter is applied to the phase maps using image convolution technique (Ghiglia, 1998), being the select noise points

updated in each iteration. The filtering process stops when the average phase changes are smaller than a predefined level.

RESULTS AND CONCLUSIONS

The average phase steps of the reference and deformation states are shown in Fig. 1. In these histograms are observed that the average phase step presents a Gaussian distribution centre in π/2 and are similar for both phase maps. The phase step dispersion is result of partial or total speckle decorrelation.

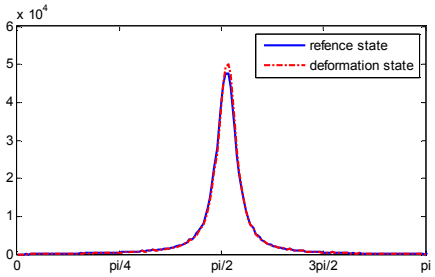
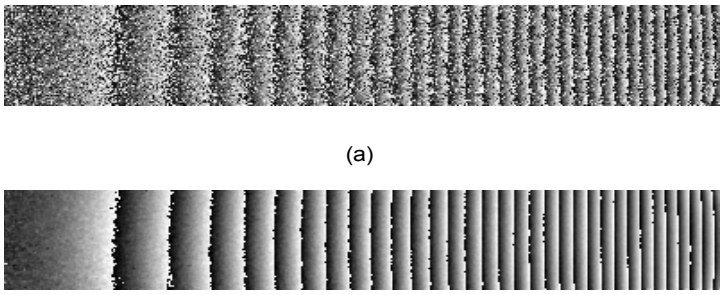


Fig. 1 - The average phase step histograms.

The phase map of the clamped-free aluminium beam rotation field (260 mm long, 45 mm width and 2 mm thick), measured with speckle shearography technique, and the corresponded filtered phase map obtained using the present phase filter technique are shown in Fig. 2. In these maps is observed that was possible to correctly remove the noise and preserved the original phase information, even for very low signal-to-noise ratio regions (left edge).



(a)

(b)

Fig. 2 - Phase maps: (a) original (b) filtered with the proposed technique.

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