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An Anti-rigid-body Motion Image Processing Method for Electronic Speckle Pattern Interferometry

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Summary

Electronic speckle pattern interferometry (ESPI) is a full-field non-contact optical technique for displacement and vibration measurement. This study presents an anti-rigid-body motion (ARM) image processing method to improve the image quality of time-averaged ESPI method. The ARM method is based on the statistical optics and has the ability to reduce the perturbed rigid-body motion and background brightness influence. Finite element method (FEM) is applied to evaluate the resonant frequency and mode shape of piezoelectric ceramics, and compared with experimental measurements. In the resonant frequency comparison, ARM method presents 0.13% and 0.82% discrepancy in the third in-plane mode for U and V direction, indicating that ARM method can be used to precisely determine the resonant frequency. In the mode shape comparison, ARM method presents an excellent agreement with FEM results, indicating that ARM has the ability to present a clear vibration mode shape. To investigate the image quality of ARM method, this study uses Canny edge detection to separate and analyze the statistical information on every bright fringe. Fringe analyses indicate that ARM method can simultaneously reduce perturbed rigid-body motion and background brightness influence. Image quality comparison between subtraction, mean and ARM method indicates that ARM method preserves both advantages of two methods and improves image quality. Compared with subtraction method, ARM method increases 29% mean value and reduces 13% standard deviation value in average. Compared with mean method, ARM method reduces 75% mean value and increases 24% standard deviation in average. From theoretical, numerical and experimental results, this study confirms that ARM method has the ability to resist perturbed rigid-body motion and background brightness influence, providing a better image quality for time-averaged ESPI method.