

RECENT ADVANCES IN INTEGRITY-RELIABILITY-FAILURE

J.F. Silva Gomes, Shaker A. Meguid
Editors



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EDITORS PREFACE

As the engineering community continues to cross the boundaries of known practices, materials and manufacturing techniques into the frontiers of new functional materials, environments and applications, the opportunities for catastrophic failures will inevitably increase. If our knowledge of how to engineer systems, structures and components to minimize or prevent catastrophic failure is to keep pace with modern manufacturing technologies, the demanding applications, and the intolerance of a safety conscious society, we must continue our efforts to develop and use superior materials, apply reliable analytical techniques and validate these with sound experimental tools. It is with this in mind that this series of conferences was organised.

The objectives of this gathering are to provide a forum for the discussion and dissemination of recent advances in assessing the integrity, reliability and failure of engineering structures, components, and assemblies, foster research in these areas, and promote international co-operation among scientists and engineers in the field. The goal is to enable concerned researchers and scientists from all over the world to exchange ideas on mechanics, materials and design as they relate to system integrity and reliability.

This fourth international conference, which is sponsored by the University of Porto, the University of Toronto and the University of Madeira, is part of a prestigious series of Integrity Reliability and Failure conferences coordinated by the International Scientific Committee on Mechanics and Materials in Design. The conference attracted over 300 participants with 380 accepted submissions from 45 different countries around the world. These papers were presented in June 23-27, 2013 in the magnificent city of Funchal, Madeira. The conference themes which address integrity, reliability and failure focused on Analytical and Numerical tools, Testing and Diagnostics, Surface and Interface Engineering, Sensors and Instrumentation, Tribology, Mechanical Design and Prototyping, Modes of Failure, Composite Materials, Nanotechnologies and Nanomaterials, Biomechanics, Energy and Thermo-Fluid Systems, Impact and Crashworthiness and Case Studies.

We are particularly indebted to the authors and special guests for their plenary lectures and presentations. Each of the more than 380 contributions offered opportunities for thorough discussions with the authors. We acknowledge all of the participants, who contributed with innovations, new research approaches, novel modeling and simulation efforts, and invaluable critical comments. We are also indebted to the outstanding plenary lecturers who highlighted the conference themes with their contributions: Professor Xiong Zhang (Tsinghua University, P. R. China), Professor E.A. Elsayed (Rutgers University, USA) and Professor Noritsugu Umehra (Nagoya University, Japan). We also take this opportunity to thank the members of the International Scientific Committee and reviewers for their time and effort.

Last but by no means least, we offer our sincere gratitude to the symposia organisers for their contribution to the success of the event and the local organising committee for attending to many aspects of the conference demands. For all of them, we are truly very grateful.

Shaker A. Meguid and J.F. Silva Gomes
Funchal / Madeira, June 2013

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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 decorrelation 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 $\pi/2$ and are similar for both phase maps. The phase step dispersion is result of partial or total speckle decorrelation.

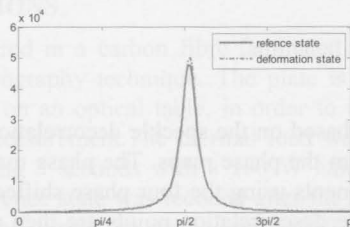


Fig. 1 - The average phase step histograms.

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).

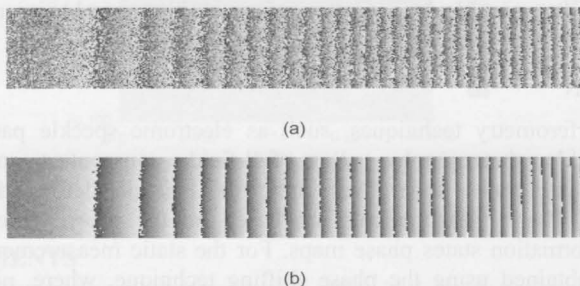


Fig. 2 - Phase maps: (a) original (b) filtered with the proposed technique.

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