Three-dimensional deformation field measurement with digital speckle correlation

Thomas Fricke-Begemann

Digital speckle correlation is based on a detailed analysis of changes in speckle images that are recorded from laser-illuminated rough surfaces. The two in-plane components are obtained by cross-correlation of corresponding subimages, a method also known as digital speckle photography. The local gradient of the hitherto inaccessible out-of-plane component is determined from the characteristic dependence of the speckle correlation on the spatial frequency. A detailed experimental study is carried out to analyze the new technique for systematic and random measuring errors. For moderate decorrelation the accuracy of the out-of-plane measurement is better than $\lambda/10$ and thus comparable with interferometric techniques. Yet the extremely simple and robust optical setup is suited to nondestructive-testing applications in harsh environments. The quality of the deformation maps is demonstrated in a practical application.

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1. Introduction

position with a reference wave. On the other hand,

the speckle patterns is then determined numerically with correlation algorithms.[5–8] The advantages over the classical form are, for example, that the digital version is much faster and easier to use and that there is no directional ambiguity, owing to the acquisition of two images. Today DSP is a versatile and easy-to-use research tool, and DSP systems for in-plane displacement-field measurements are also commercially available. Similar systems for flow

When this research was performed, T. Fricke-Begemann (tfb@llg.gwdg.de) was with the Department of Physics, Applied Optics Group, Carl von Ossietsky University, Oldenburg, Germany. The author is now with Laser-Laboratorium Göttingen, Göttingen, Germany.

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