Multiplexing and de-multiplexing of digital holograms recorded in microscopic configuration

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Summary

We investigate the possibility to multiplexing and de-multiplexing numerically digital holograms recorded by means of a Mach–Zehnder interferometric microscope.

Two kind of multiplexing techniques are investigated. The first one allows to multiplex up to hundreds of digital holograms retrieving correctly their amplitude and phase maps. This technique can be used to optimize the storage and transmission process. The second method consists in the angular multiplexing and de-multiplexing of digital holograms, rotating numerically one hologram at different angles and adding the rotated holograms to obtain a synthetic digital hologram. The distortions caused by the proposed procedures has been evaluated.

Introduction

Digital Holograms (DHs) can be multiplexed by encoding the information of two or more holograms in a single one. Multiplexing of digital holograms has been used to measure some object properties, as the state of polarization, dynamical phenomena or three-dimensional mechanical deformations by a single image acquisition [1,2]. In the above mentioned approaches, spatial multiplexing of digital holograms is obtained optically, that means recording simultaneously more then one fringe pattern on the same sensor array. All the holograms are superimposed in one composite CCD frame, and each of them can be independently reconstructed after the digital spatial filtering in the Fourier spectral domain of the multiplexed hologram. However, the multiplexing operation can be carried out also by numerical techniques by combining numerically digital holograms to obtain a single synthetic hologram. Recently, we demonstrated that an efficient storage and/or transmission of a large number of DHs can be attained by numerical multiplexing (NM) method [3]. On the other hand, we studied also a different approach to encode information from various digital holograms acquired in microscope configuration in a multiplexed one, through the angular rotation of the digital holograms around their optical axis.

Experimental Methods

In both the mentioned approach, reported in the following sections, we exploit the unique capability of DH to manage numerically the complex wavefronts, to reconstruct the object wave field at an intermediate plane, that is, essentially, the back focal plane (BFP) of the imaging lens. In fact, the multiplexed holograms are acquired by means of a Mach-Zehnder interferometric microscope, shown in Fig.1.

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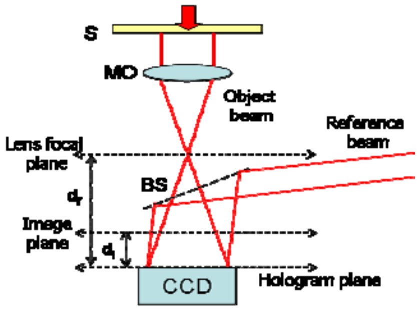
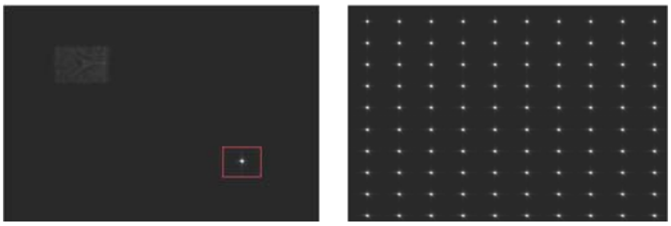


Fig.1. Sketch of the DH setup; S: sample; BS: beam splitter; MO: microscope objectives

In the BFP of the imaging lens, the complex-value array, corresponding to the object wavefield, is proportional to the Fourier transform of the complex amplitude of the wave at an input plane. Therefore, we obtain only the spectrum of the object wave field.



(a) (b)

Fig.2. (a) Amplitude reconstruction of one hologram in BFP. The red frame indicates the used filtering window around the carrier frequency of the object spectrum. (b) Amplitude of the synthetic spectrum obtained by the numerical multiplexing in the BFP of 100 digital holograms.

As to the first multiplexing/de-multiplexing technique, in fig. 2 are shown, respectively, the amplitude reconstruction of one hologram in the BFP and the amplitude of the synthetic spectrum obtained joining together the 100 spectra, filtered by means of the filtering windows (indicated by the red frame). This complex-value array contains the information about the phase and amplitude of all one hundred holograms.

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