

Optical reconstruction of digital off-axis Fresnel holograms using phase-only LCOS SLM “HoloEye PLUTO VIS”

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Abstract. Optical reconstruction of digital holograms using SLM is used for imaging of 3D scenes, interferometry, microscopy, and etc. In this article reconstruction of digital off-axis Fresnel holograms using phase-only LCOS SLM “HoloEye PLUTO VIS” is described. Experimental and numerically simulated results of reconstruction are presented.

1. Introduction

Spatial light modulators (SLMs) [1] are widely used for displaying of diffractive optical elements. Optical reconstruction of digital holograms is one of the most important tasks [2-5] and is used in different areas of science and industry: imaging of 2D and 3D scenes [2-3], interferometry [4], microscopy [5], and etc.

Since recorded with digital cameras holograms are amplitude type, they have such disadvantages as low diffraction efficiency, necessity of spatial separation of informative diffraction order from undesired orders, and etc. [3]. In addition, quality of reconstructed images from holograms is influenced by noise and linear dynamic range of registering camera [6], characteristics and type (amplitude or phase) of used SLM [7]. Quality of hologram optical reconstruction with phase SLM is worse compared to amplitude SLM. However, application of phase SLM can provide higher diffraction efficiency.

In this article experiments on optical reconstruction of digital off-axis Fresnel holograms displayed on phase-only liquid crystal on silicon spatial light modulator (LCOS SLM) “HoloEye PLUTO VIS” are described.

2. Description of setup for optical reconstruction of digital Fresnel holograms using SLM

Images from digital holograms were optically reconstructed using phase-only LCOS SLM “HoloEye PLUTO VIS” [8]. SLM works “in the reflection” and has following characteristics: quantity of pixels is 1920×1080 , pixel size is $8 \mu\text{m} \times 8 \mu\text{m}$, maximum frame rate is 60 Hz, quantity of phase levels is 256 (8 bit).

Setup scheme for optical reconstruction of digital holograms using SLM is shown in Figure 1. The source of light is a 10 mW HeNe laser with wavelength 633 nm. Laser beam passing through polarizer and collimator consisting of microscope objective, pinhole and collimating lens expands to size of approximately 20 mm in diameter. Then this beam reflecting from displaying digital hologram SLM forms reconstructed wave and passes through analyzer. Computer is used for the SLM control and



digital holograms display on the SLM. Scientific digital camera Megaplug II ES11000 was used for reconstructed images registration. Camera is monochromatic and has following characteristics: quantity of pixels is 4008×2672 , pixel size is $9 \mu\text{m} \times 9 \mu\text{m}$.

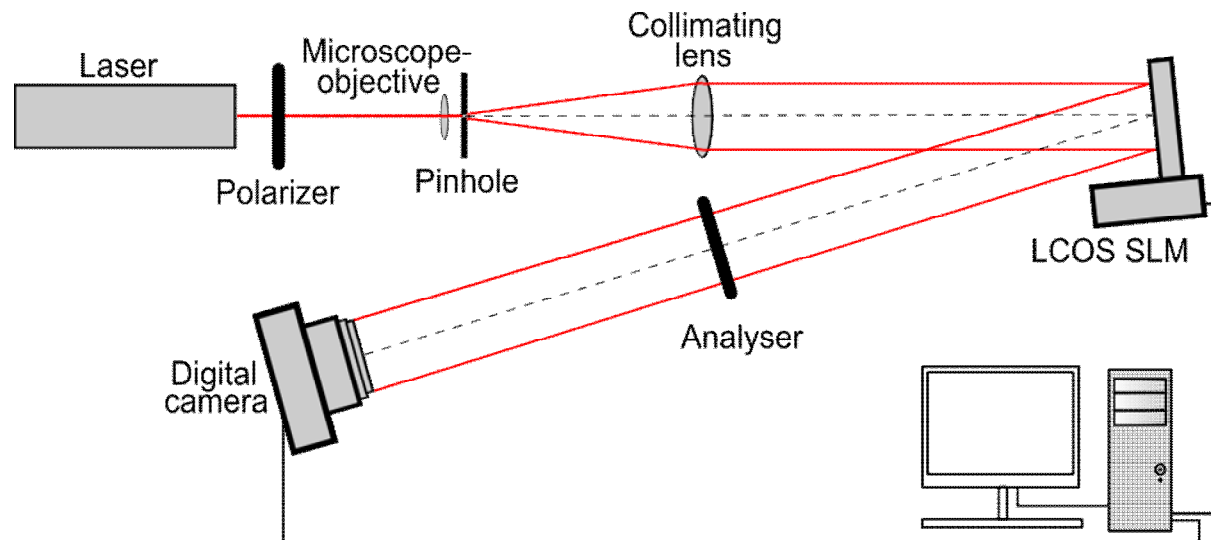


Figure 1. Setup for optical reconstruction of digital Fresnel holograms using LCOS SLM.

Resolutions of displayed digital holograms were limited to the SLM resolution.

3. Experimental and simulated reconstructions of digital Fresnel holograms using phase-only SLM

For experimental and simulated optical reconstruction of digital off-axis Fresnel holograms, earlier recorded [9] holograms were used. Quantity of pixels of these holograms is 2048×2048 . For experiments, central regions of the holograms with size of 1920×1080 pixels were chosen. Holograms were optically reconstructed with its display on the phase-only SLM. Fragments of reconstructed images were registered by camera Megaplug II ES11000. Example of reconstruction of one hologram is shown in Figure 2a. Higher noise level on left part of image is caused by presence of undesired zero diffraction order.

For comparison, Figure 2b shows image fragment obtained by modeling of optical reconstruction of hologram using phase-only SLM. Modeling of optical reconstruction was carried out as follows. Firstly quantity of pixel signal levels was decreased to 256. Then modeling of hologram displaying on phase-only SLM was performed. It was supposed that value of phase shift introduced by pixel of SLM is directly proportional to signal value of pixel of digital hologram. As a result, amplitude of modeled wave that incident onto SLM did not change after transmission through the SLM or reflection from SLM. Only its phase changed. Modeling of wave propagation from SLM plane to plane of image reconstruction was accomplished with method of direct calculation of Fresnel diffraction (through one fast Fourier transform [3, 9]).

As seen from Figures 2a and 2b, quality of experimental reconstruction is quite similar to results of numerical modeling. Higher level of noise of experimentally reconstructed image is due to temporal fluctuations of phase modulation of LCOS SLM [10].

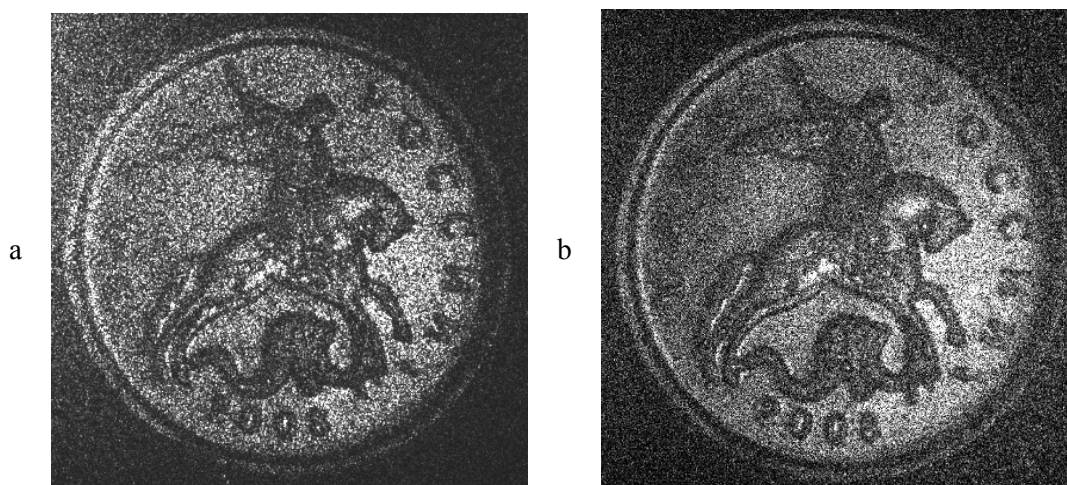


Figure 2. Experimental (a) and numerically simulated (b) digital Fresnel hologram reconstruction using phase-only SLM.

To decrease temporal fluctuations of SLM, synchronization of SLM and registering camera can be used [11]. This will allow to improve quality of digital hologram reconstruction.

4. Conclusion

Experiments on optical reconstruction of digital off-axis Fresnel holograms using LCOS SLM were performed. Experimental and simulated results of reconstruction are compared and are close to each other. Synchronization of SLM and registering camera is proposed to improve quality of experimental reconstruction.

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