Digital holographic imaging of specular reflective objects

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1. Introduction

Digital holography [1] is a technique to optically record 3D field on image sensor array e.g. CCD/CMOS and re-construct it numerically. The object beam carries the in-formation of object to the sensor where it is superim-posed with reference beam to create interference pattern. The object beam is a combination of properties of illumina-tion beam and object. Thus, the properties of illumination beam can affect the recorded information of object. In the experiments of digital holography, the illumination beam is mostly either spherical or collimated and so is the object beam. These types of object beams can't image a specular reflecting object's surface completely because of definite size of image sensor's active medium. When the light field reaching the sensor is spherical or collimated, then only the light field illuminating the active medium of the sensor is recorded which contains information of a certain portion of specular object. This limitation can be overcome by using a diffuser in the illumination beam [2,3]. A diffuser random-izes the phase of illumination beam and makes the object beam diffused. Thus, information from all portions of the object is diffusely scattered and reaches the image sensor which records all the information of object within its field of view [4].

In this paper, a specular object is imaged in off-axis digital holographic experiment by changing the property of the illumination beam using a diffuser.

2. Experiment

A scheme of off-axis digital holographic arrangement used in this experiment is shown in Fig. 1.

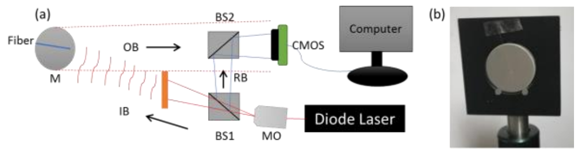

Fig. 1. (a) Scheme of off-axis digital holographic experimental setup, (b) Mirror used as object with a fiber fixed on its surface. MO: Microscope objective; BS: Beam splitter; IB: Illumination beam; M: Mirror; OB: Object beam; RB: Reference beam.

A diode laser source (Wavelength – 660 nm, Power 24mW) is diverged by a 40X microscope objective. This diverged beam is divided into illumination beam and refer-ence beam by a beam splitter. The illumination beam illu-minates the diffuser to create a diffused beam which illu-minates the mirror and gets scattered from it to create the object beam. The object beam and reference beam are combined by another beam splitter and superimposed to create an interference pattern which is recorded by CMOS sensor. The recorded interference pattern is called as digital hologram and is stored in computer for further processing. The object used here is a specular reflective mirror on which a fiber of 200 μm diameter is fixed to create a defect.

3. Results

Two digital holograms are recorded using experimental setup i.e. with and without using diffuser in illumination beam. The recorded digital holograms are reconstructed using Fresnel diffraction wavefront reconstruction method [5]. Figure 2 shows the reconstructed images.

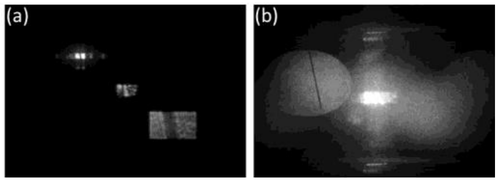

Fig. 2. (a) Images of reconstructed wavefront of mirror (a) without and (b) with diffuser in illumination beam

It can be observed in Fig. 2(a) that, without diffuser a certain portion of the mirror is recorded. The reason is spherical object beam which allowed only small portion of object to reach the active medium of the CMOS sensor. While, with diffuser, whole surface of the mirror with fiber fixed on its surface, is reconstructed as shown in Fig. 2(b).

The illumination beam, after passing through the dif-fuser, creates a diffused beam of random phase. This dif-fused beam is scattered after reflection from the object to create object beam. Due to this diffusely scattered object beam, information from whole surface of the mirror is rec-orded by CMOS sensor and reconstructed using Fresnel diffraction method.

3. Conclusions

Complete surface of a specular reflective mirror is rec-orded and reconstructed in digital holography by changing the properties of illumination beam using a diffuser. The diffused illumination of specular reflective object elimi-nates the limitation applied by spherical illumination beam and definite size of active medium.

References

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