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Single-shot color digital holography based on spatial frequency-division multiplexing and space-bandwidth capacity-enhance

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1. Introduction

Digital holography [1] is a technique for recording a digital hologram to obtain the wavefront of an object wave and then reconstructing both the three-dimensional (3D) and quantitative phase images of the object using a computer. Color information is obtained by recording multiple wavelengths, which is called color digital holography [2]. Color digital holography utilizing spatial frequency-division multiplexing [3] is implemented with a single-shot exposure of a monochromatic image sensor by using a reference beam. However, Space bandwidth available for recording an object wave is severely restricted and the crosstalk between the object waves with different wavelengths occurs easily when capturing a 3D area.

In this paper, we propose single-shot color digital holography with wide space-bandwidth based on spatial frequency-division multiplexing. Experimental results show the effectiveness of the proposed digital holography.

2. Principle

Figure 1 shows a schematic of a color digital holography system based on spatial frequency-division multiplexing. Spatial frequency of interference fringes is determined by sin θ/λ, where θ and λ are the angle between object and reference waves and wavelength for recording a hologram, respectively. Spatial frequency spectra is separated by the difference of λ and object waves with different wavelengths are separately extracted. Therefore, a multicolor hologram is multiplexed in the space domain and separated in the spatial frequency domain. However, most of the space-bandwidth of an image sensor is discarded when difference of wavelengths is a little and crosstalk between object waves with different wavelengths occurs easily. To solve the narrow space bandwidth, we introduce space-bandwidth capacity-enhance (SPACE) [4,5]. Please see the detail of SPACE in refs. 4 and 5.

3. Experimental results

An experiment was conducted to verify the effectiveness of the proposed technique. A multicolor hologram was obtained by two lasers operating at 532 nm and 640nm, respectively, and a CMOS monochromatic image sensor [3840 (H)×2764 (V) pixels, pixel size: 1.67 μm × 1.67 μm]. A miniature model of a lion was set as the object and the distance z was 505 mm. The size of the object was 20 mm (H) × 17 mm (V). Each hologram required for the conventional and proposed techniques was obtained by the same optical setup and with changing the incident angle of the single reference beam. Figure 2 shows the experimental results. Crosstalk between the object images with

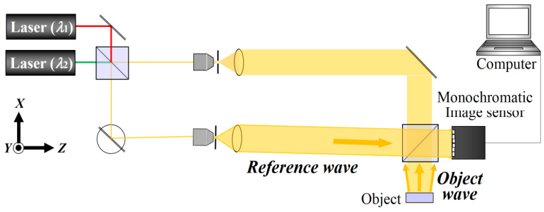

Fig. 1. Schematic of a color digital holography system based on spatial frequency-division multiplexing.

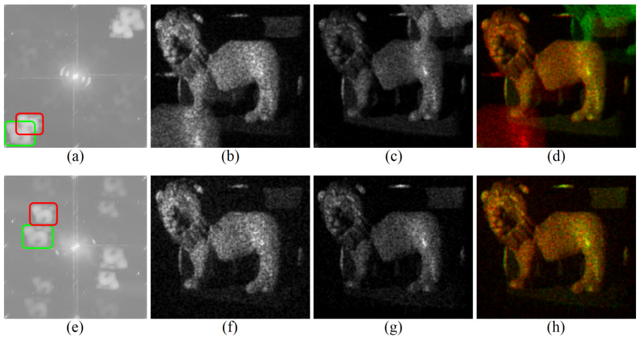

Fig. 2. Experimental results. (a) Spatial frequency distribution of a hologram, reconstructed images (b) at 640 nm, (c) at 532 nm, and (d) the color-synthesized image obtained by the conventional technique. (e) Spatial frequency distribution of a hologram, reconstructed images (f) at 640 nm, (g) at 532 nm, and (h) the color-synthesized image obtained by the proposed digital holography. Red and green rectangles show the spectra of the object waves at 640 nm and 532 nm, respectively.

different wavelengths was not avoided by the conventional technique due to the severely narrow space-bandwidth. In contrast, clear object image in each wavelength was obtained by the proposed digital holography.

4. Conclusion

Single-shot color digital holography with wide space-bandwidth based on spatial frequency-division multiplexing was proposed. Wide space-bandwidth in each wavelength was achieved by the assistance of SPACE. The proposed holography will contribute to high-speed multi-color 3D motion-picture sensing applications.

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