International Symposium on Holography and Related Technologies 2015 (IWH2015)
Ginowan (Okinawa), We5-P8, (2015.12.2).

# Capture of Large-Scaled Wave Fields for Full-Color Digitized Holography

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## 1. Introduction

In the past few years, computer holography successfully created high-definition computer-generated holograms (CGH) such as “Brothers” and “The Venus” [1]. In these CGHs, the 3D images of polygon-meshed CG models, i.e. virtual objects are optically reconstructed with the strong sensation of depth. However, high-definition CGHs reconstruct not only virtual objects but also real-existing physical object. In this case, the wave field emitted from physical objects is recorded by employing synthetic aperture digital holography (DH) and optically reconstructed by high-definition CGHs [2]. We call this technique digitized holography, because the whole process of traditional holography is digitized in this technique.

Recently, full-color reconstruction of high-definition CGHs for virtual objects is also realized by using dichroic mirrors [3] and color filters [4]. Thus, it is properly expected that physical objects can be reconstructed in full-color. However, three object fields of a physical object must be recorded with three wavelengths corresponding to RGB primary colors to reconstruct its full-color 3D images. In this paper, the technique of synthetic aperture DH with RGB three wavelengths is reported for realizing full-color digitized holography. Full-color simulated reconstruction of the generated CGH is also presented to verify the technique.

## 2. Recording object fields by synthetic aperture DH

Figure 1 shows the experimental setup for synthetic aperture DH with three wavelengths corresponding to RGB primary colors. The parameters used in the experiment are summarized in Table 1. The image sensor mounted on stages scans the area of the object field and records the fringe generated by optical interference. The phase shifting technique is used for removing the conjugate image and 0-th order light. Lensless Fourier setup using a spherical reference field makes it possible to convert the sampling density. In this experiment, we actually recorded the object fields over the area of approximately $11.4 \times 11.4$ cm$^2$ at interval of less than 1 μm. Here note that three fringes are recorded for phase shifting prior to changing the wavelength, because the amount of phase shift depends on the wavelength. After recording three fields at a given position, the image sensor stages moves 10 mm in horizontal or 7.2 mm in vertical direction.

Figure 2 shows captured fields and Fourier-transformed object fields. Since sampling interval depends on the wavelength, we resampled the field using bicubic interpolation to adjust the interval of all captured fields to 1μm.

Table 1 Parameters used for capturing object fields.

| | |
|---|---|
| Wavelengths [nm] | 488, 532, 633 |
| Number of samplings used for numerical calculation | $32{,}768 \times 32{,}768$ |
| Sensor pitches [μm] | $3.5 \times 3.5$ |
| Number of segments | $12 \times 16$ |
| Distance between reference point source and sensor [mm] | 250 |

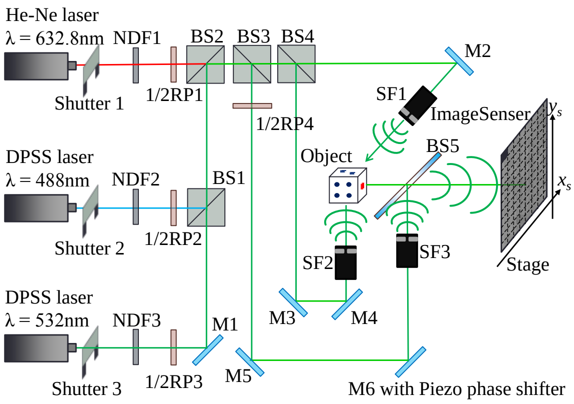



Fig.1 Experimental setup for capturing large-scaled wave-fields by using lensless-Fourier synthetic aperture DH.

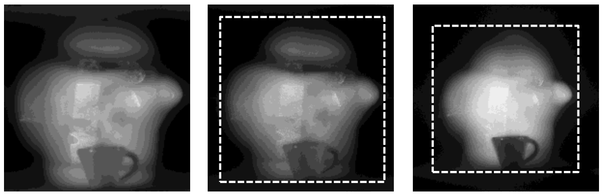
## 3. Simulated reconstruction of full-color CGHs

A fringe pattern was generated for creating the high-definition CGH and reconstructing the captured field. The 3D scene and parameters are shown in Fig.3 and Table 2, respectively. Figure 4 shows full-color simulated reconstructions from different viewpoints, which are calculated by the numerical image formation technique. Here, we assumed the optical system using dichroic mirrors for full-color reconstruction [3].

It is verified that the object fields are properly recorded by the proposed technique, but a little color changes are observed when the viewpoint continuously moves. Vertically-striped noises also occurs in the reconstructed images.

λ=488nm λ=532nm λ=633nm

(a) Captured wave fields (amplitude image)



λ=488nm λ=532nm λ=633nm

(b) Fourier-transformed images (amplitude image)

Fig.2 Captured object fields with three wavelengths

## 4. Conclusion

We proposed the technique for capturing large-scaled object fields using synthetic aperture DH with RGB three wavelengths. The full-color 3D image is successfully reconstructed by the CGH generated from the captured fields in simulation, though several degradations are found in the reconstructed images.

This work was supported by the JSPS KAKENHI (15K00512) and the MEXT strategic research foundation at private universities (2013-2017)

Table 2 Parameters used for creating the CGH.

| | |
|---|---|
| Number of samplings | 32,768 × 32,768 |
| Pixels pitches [μm] | 1.0 × 1.0 |
| Design wavelength [nm] | 488, 532, 633 |

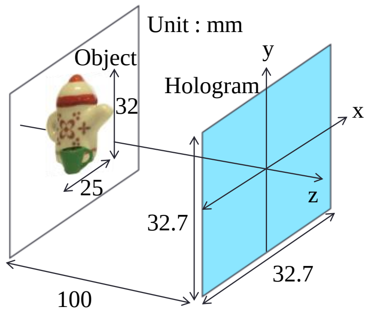



Fig.3 3D scene of the CGH.

## Reference

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3) T. Miyaoka, K. Matsushima, S. Nakahara: "Optimization of design-wavelength for unobtrusive chromatic aberration in high-definition color computer holography", SPIE Proc. **9386**, 93860N (2015).
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Left Canter Right

Fig.4 Full-color simulated reconstruction of the captured fields using dichroic mirrors.