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Large-Scale Full-Parallax Full-Color Computer-Generated Holograms Reconstructed by Laser/LED Lighting

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Abstract: *Two techniques are introduced to create full-color computer-generated holograms that have very large-scale such as tens of billion pixels and reconstruct a very impressive deep 3D scene. In the techniques, white LEDs and RGB laser are used as the illumination light source. Optical reconstruction of these full-color CGHs are demonstrated in this paper.*

1. Introduction

Computer holography, the technique to create holographic 3D images using a computer, has been developed over the last decade [1]. The created holograms, called computer-generated holograms (CGH), can reconstruct 3D images of non-physical objects unlike traditional optical holography. Unfortunately, creating high-quality CGHs had been impossible for a long time because of the gigantic space-band product required for realizing a given large viewing angle and screen size. We developed several techniques that make it possible to calculate and fabricate large-scale CGHs, called high-definition CGHs, which are composed of billions or sometimes tens or hundreds of billion pixels (Chap. 1 in [1]). The large-scale CGHs reconstruct spatial 3D images of a deep scene with natural motion parallax in full-parallax. The 3D images, in fact, are being comparable to those in traditional optical holography. As a result, the CGHs give great impact of strong sensation of depth to viewers.

However, it was very difficult to reconstruct full-color images by these high-definition CGHs because the printed CGHs are a type of thin hologram. The 3D images reconstructed under a white-light illumination cause many smears because of chromatic aberration. Recently, two methods: CGHs with RGB color filters [2, 3] and stacked CGVHs (computer-generated volume hologram) [4] were invented for reconstructing full color images from high-definition CGHs. These full-color CGHs are reconstructed using a white LED or RGB laser light sources.

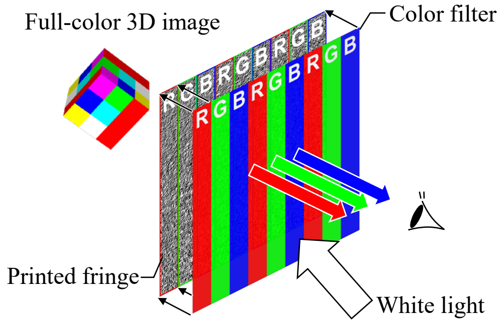

Fig. 1. Full-color reconstruction of high-definition CGHs using RGB color filters.

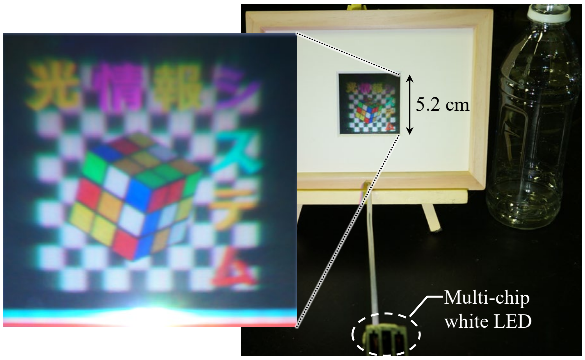

Fig. 2. Full-color reconstruction of a high-definition CGH using RGB color filters [2]. Video link, https://doi.org/10.1364/OE.25.002016.v001

2. CGH with RGB color filters

In this technique, RGB color filters that are very similar to those used in LCD panels are attached to the large-scale fringe pattern, and the fringe pattern behind the filters is generated at appropriate wavelengths corresponding to the RGB colors, as shown in Fig. 1.

2.1 Illumination light sources

CGHs with RGB color filters can be reconstructed by both LEDs and RGB lasers. When using an LED, because the bandwidth of the RGB color filters is commonly not so narrow, a multi-chip type white LED should be used instead of a single-chip type with phosphor to reconstruct sharp 3D images. The problem of the bandwidth is properly avoided by use of an RGB laser source.

2.2 Optical reconstruction

Optical reconstruction using a multi-chip white LED is shown in Fig. 2. The 3D image is blurred a little by the wideband property of the illumination. Coherent illumination using an RGB laser makes the reconstructed image much sharper as shown in Fig. 3. Here, an ultra-short focus projector made by SONY™, where RGB laser diodes (LD) are installed, is used for the light source, as in (d). Note that the projector throws just a plane white image in this case. We can also use discrete RGB-LD components for the illumination, as in (e).

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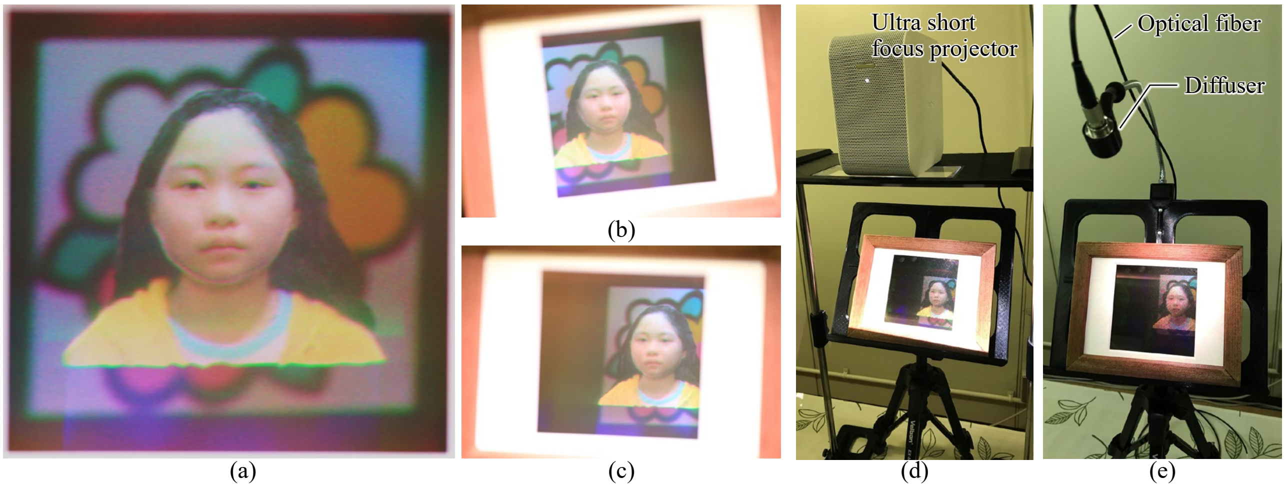

Fig. 3. A CGH with RGB color filters reconstructed using RGB lasers. A close-up image (a), and images from (b) left and (c) right viewpoints (Sect. 15.6.4 in [1]); Illumination using (d) a laser projector and (e) RGB laser.
Video link, https://youtu.be/DmC93CRdhFQ

3. Stacked CGVH

Another way to reconstruct full-color 3D images from a high-definition CGH is stacking computer-generated volume holograms (CGVH) [4]. A volume hologram, sometimes called a "thick" hologram, is a different type of hologram. The volume hologram cannot be created by printing the fringe pattern because the fringe has a 3D structure in the recording material such as photopolymer. We can fabricate CGVHs by transferring the original CGH, printed using laser lithography (Sect. 15.3 in [1]), to photopolymer using the technique of contact-copy.

A volume hologram has strong wavelength selectivity based on Bragg reflection, and can be reconstructed by reflection illumination only at wavelength used in the contact copy. Thus, we can reconstruct full-color images by fabricating three CGVHs from three original printed CGHs and stacking the CGVHs, as shown in Fig. 4. The hologram reconstructs very fine 3D images shown in Fig. 5 using a single-chip white LED, which has a broadband property, because of the excellent wavelength selectivity of the CGVHs.

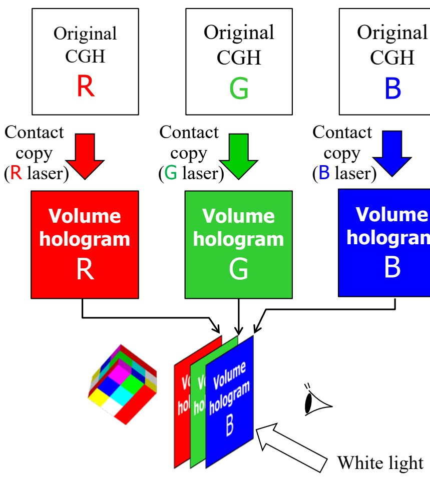

Fig. 4. The principle of stacked CGVHs.

4. Conclusion

Full-color reconstruction of large-scale CGHs is achieved by two methods using a white LED and RGB laser light source.

Acknowledgment

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References

[1] K. Matsushima, *Introduction to Computer Holography* (Springer, 2020).
[2] Y. Tsuchiyama and K. Matsushima, "Full-color large-scaled computer-generated holograms using RGB color filters," Opt. Express **25**, 2016–2030 (2017).
[3] K. Matsushima and N. Sonobe, "Full-color digitized holography for large-scale holographic 3D imaging of physical and nonphysical objects," Appl. Opt. **57**, A150–A156 (2018).
[4] O. Kunieda and K. Matsushima, "High-quality full-parallax full-color three-dimensional image reconstructed by stacking large-scale computer-generated volume holograms," App. Opt. **58**, G104-G111(2019).

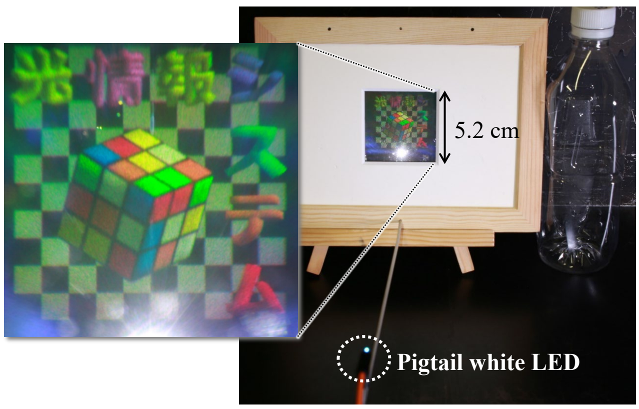

Fig. 5. Full-color reconstruction of the stacked CGVH using a broadband pigtail white LED [4]. Video link, https://doi.org/10.6084/m9.figshare.8870177.v1