Representation of full color high-definition computer-generated holograms

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Abstract: The representation of full color high-definition computer-generated hologram (CGH) is obtained with a basic masking and combination technique of R/G/B CGH components. This technique allows you to ease the actual process of the coloring of high definition CGH. In this paper, the coloring technique is proposed and the numerical analysis of is presented.

1. Introduction

High-definition computer-generated hologram (CGH) has actively been developed and studied by numerous researchers, because they can show high-quality three-dimensional (3D) holographic images [1]. The most important element in high-definition CGH is how to synthesis of the object after segment and perform fast calculations. This is because the area is very large that it requires huge computational time and requires great memory. Therefore, the synthesis and segmentation of the high-definition CGH and fast calculation method can be said to be one of the core technologies of the holographic 3D display [2]. One important issue is coloring of high-definition CGH. The coloring is relatively new topic in this field. Recently, the full-color CGH with color filter layer of basic striped R/G/B pattern was demonstrated in Y. Tsuchiyama et al. [3]. In this paper, the representation of full-color high-definition CGH is presented with spatial multiplexing of R/G/B CGH component. Various masking and combination technique of R/G/B component is methods to make real observations without difficulty. We will first introduce how we segment high-definition CGH in viewing zone, and talk about the necessity and performance of coloring masking techniques.

2. Representation of full-color CGH

First, we will explain how to segment and synthesize large-scale and high-definition CGHs. For the calculation, large-scale high-definition CGH, the traditional segmentation method performs division in the object plane, while the approach we propose is the division in the viewing zone. Traditional segmentation method and our method are compared in the Figs. 1(a) and 1(b). Although the two partitioning methods do not seem to be different, many techniques can be applied to enhance the quality of CGH when using the proposed method. The key to the synthesis method is to multiply the carrier waves by CGH for each direction and combine them. To be more precise, there is one signal data and there are several carrier waves in each direction. Multiply the signal data by carrier wave according to direction, and then combine the results. The formula for this is as follows:

$$CGH_{total} = \sum_{m}\sum_{n} \exp\left(j\left(k_{m,n,x}x + k_{m,n,y}y + k_{m,n,z}z\right)\right) F_{m,n}(x,y), \tag{1}$$

where m, n are the indices of viewing direction and $F_{m,n}(x,y)$ and $\exp\left(j\left(k_{m,n,x}x + k_{m,n,y}y + k_{m,n,z}z\right)\right)$ are complex signal and carrier wave terms, respectively.

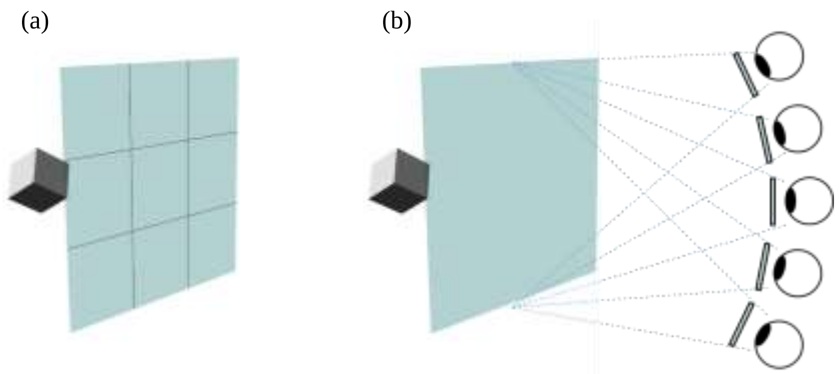

Fig. 1. (a)Traditional and (b) our segmentation method for calculation of large-scale high-definition CGH

Next, we will show you how to use color masking technique for synthesizing full-color high-definition CGH. A color masking scheme for vertically representing red, green, and blue in consideration of a color filter has been studied [3]. This structure and arrangement is very advantageous for the color filter process and can achieve a good color expression depth. The arrangement, structure, and technique of various coloring mask patterns are shown in Fig. 2. One method

(Fig. 2(a)) is the pseudo random coloring mask method where small size groups R/G/B pixels are randomly distributed and the other (Fig. 2(b)) is the periodic coloring mask method where R/G/B pixel components are regularly arranged. This type of mask will act as a sort of filter, and it is expected that the image quality will be degraded because each color uses only 33% of the area. Also, degraded image quality can be mitigated by increasing resolution. The total full-color CGH with the mask applied is generated through the process shown in Fig. 2(c).

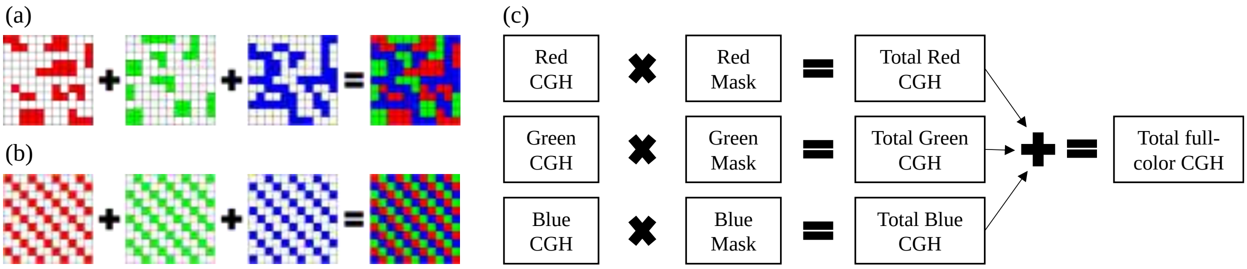

Fig. 2. Schematics of (a) Pseudo random mask method and (b) Periodic mask method. (c) Process of making total full-color CGH

Fig. 3 shows the result of reconstructed images when applying the mask technique to the CGH. When a pseudo random mask is applied, the reconstructed image and mask pattern are shown in Fig. 3(b) and the results of the periodic mask are shown in Fig. 3(c). If you apply the mask technique through the simulation results below, you can see that the picture quality is worse than the existing result (Fig. 3(a)) as expected.

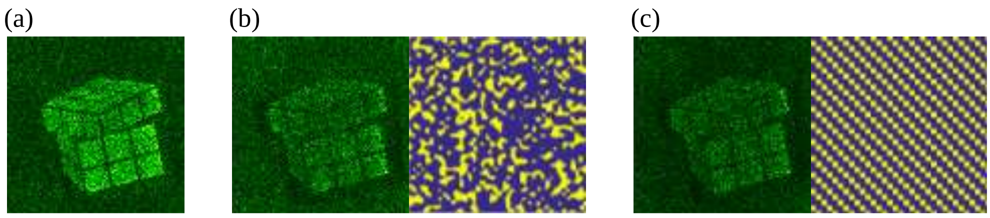

Fig. 3. Reconstructed holographic image by (a) binary amplitude-type CGH, using a mask technique of (b) pseudo random, (c) periodic

Our future work is to identify the phenomena that occur in the full color simulation with the proposed masking structure and to conduct the experiment through the actual process.

3. Conclusion

In conclusion, the full color high-definition CGH representation have been studied. We introduced the segmentation high-definition CGH in viewing zones. We also explained how to multiply the divided CGH by carrier wave in each direction and synthesize it. Finally, we introduced a pseudo random mask and a periodic mask in masking technology. By applying this technique to synthesized CGH, we have opened the possibility of making the actual process of the color filter easier and increasing the viewing angle.

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