High-definition polygon computer-generated hologram synthesis with viewing zone separation

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***Abstract*—In this paper, we propose a novel method of high-definition (HD) polygon computer-generated hologram synthesis using viewing zone separation.**

Keywords-digital holography; holographic display; computer-generated hologram; high-definition

I. Introduction

It may be said that computer-generated holograms (CGHs) synthesis algorithm is one of core technology of holographic three-dimensional (3D) display. To achieve the real-time generation of photorealistic holographic 3D scenes, in the field of CGH study, effort is chiefly directed at two directions. The first is the fast calculation method of large-scale CGH, and the second is the extraordinarily realistic description of the 3D object. For improvement of computing speed, parallel computing technique based on the graphics processing unit (GPU) is commonly used. Besides, in polygon CGH, accelerated synthesis algorithm based on theoretical property without any parallel computing hardware is also studied in our previous research [1]. Also, representation theory is as much significant as fast computation in CGH synthesis algorithm. Representation technique includes occlusion culling and rendering such as texturing, shading, etc.

To reconstruct a fine holographic 3D image, computation of large-scale CGH is imperatively necessary. Many techniques for handling of high resolution CGH have been developed, however, it is still very hard and actually impractical. In [2], computation method of large wave fields using the segmented frame buffer is presented without store whole wave field in memory. In the conventional CGH synthesis method, the wave propagation from the object plane to the SLM plane is calculated at one go. Actually, since the diffraction field of the triangle unit in the object plane covers only small region of whole area, the calculation in the object field with additional propagation is faster than the direct calculation in the SLM plane. However, in this method, the maximum diffraction area of each polygon should be calculated, and shifted Fresnel transform for off-axis wave propagations is also required.

In this paper, we propose a novel method of high-definition (HD) polygon computer-generated hologram synthesis using viewing zone separation.

II. Larg3-scale CGH calculation

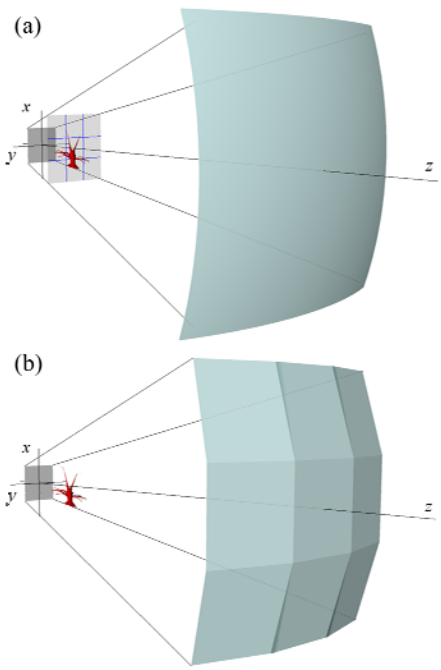

Figure 1. Large-scale CGH segmentation in (a) the conventional and (b) the proposed methods.

The traditional and the proposed methods are compared in Fig. 1. As shown in Fig. 1(a), the conventional method splits the object plane. In the proposed method, the viewing zone is segmentalized as depicted in Fig. 1(b). As a matter of fact, high resolution is necessary to describe carrier wave. In other words, high is unnecessary for representing signal. Therefore, we can calculate total CGH as in (1),

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

where m, n is the viewing direction, and $F_{m,n}\left(x,y\right)$ and $\exp\left(j\left(k_{m,n,x}x + k_{m,n,y}y + k_{m,n,z}z \right) \right)$ are signal and carrier wave respectively. This way facilitates that calculate signal by low resolution without any preconditioning process such as computation of the maximum diffraction area of each triangle.

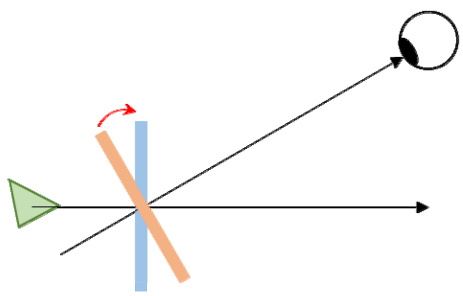

Figure 2. Computation process of the proposed method.

Figure 2 illustrates computation process of the proposed method. From every segmented viewing direction, we calculate signal in the tilted plane expressed orange color without consideration of carrier wave. Since carrier wave is not considered in this step, low resolution signal is computed. Let us assume that total resolution is $10{,}000 \times 10{,}000$ and pixel pitch is 1 μm. When the number of separated viewing zone is 10×10, signal is calculated at $1{,}000 \times 1{,}000$ resolution and 10 μm pixel pitch. Next, light field distribution at the spatial light modulator (SLM) plane expressed blue color is computed using field distribution mapping. We change the resolution into the original resolution, and multiply carrier wave. Lastly, superposition of wave field at every viewing direction is required.

Numerical simulation result is shown in Fig. 3. Figure 3(a) and (b) are amplitude and phase profile of total CGH. Signals at eye lens plane is shown in Fig. 3(c). Because we divide $11{,}011 \times 11{,}011$ resolution into 11×11 views, there are 11×11 signals. Numerically reconstructed holographic image of the center view is in Fig. 3(d).

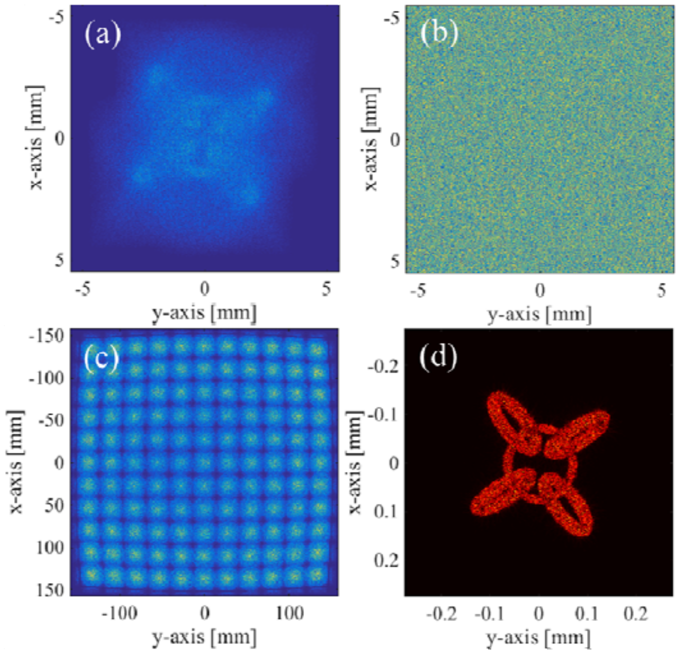

Figure 3. (a) Amplitude profile and (b) phase profile of total CGH. (c) Signals at eye lens plane. (d) Reconstructed holographic image.

III. Conclusion

We proposed a novel method of HD polygon computer-generated hologram synthesis using viewing zone separation. The process of the proposed method is elucidated in detail. The proposed method is demonstrated with numerical simulation.

Acknowledgment

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References

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