Representation of partial occlusion in polygon computer-generated hologram synthesis

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***Abstract*—The occlusion occlusion is significant for computer-generated holograms (CGHs) not merely because it is one of the representation theories, but because it is one of the most cardinal mechanisms in the perception of holographic three-dimensional (3D) scenes. In this paper, an advanced representation technique of partial occlusion for the phase-regularized polygon CGH is addressed. We demonstrates the proposed method with numerical reconstruction results.**

Keywords-digital holography; holographic display; computer-generated hologram, occlusion

I. INTRODUCTION

The technique of CGHs is one of the core technologies of holographic 3D display. To achieve the ultimate goal which is the real-time generation of photorealistic holographic 3D scenes, in the field of CGH research, attention and effort are primarily directed at two directions: the developments of (i) fast computation algorithm and (ii) representation theory. In particular, recent research has tended to concentrate on computational enhancement using the parallel computing technology based on the specific parallel computing hardware modules such as graphic processing unit (GPU). Also, the representation techniques of CGH such as texturing, shading, and occlusion are researched actively. Among these techniques, the occlusion is significant not merely because it is one of the representation theories, but because it is one of the most cardinal mechanisms in the perception of holographic 3D scenes [1].

Surfaces inside the field of view and facing the viewer may still be invisible since they can be occluded by other surfaces that are nearer to the viewer. The process of detecting such occluded objects and removing them from rendering is called occlusion culling [2]. There are two types of occlusion culling. First one is a reciprocal occlusion shielding light by other objects, and the other one is a self-occlusion of hidden-surfaces in a continuous object [3-4]. The self-occlusion is relatively simple since it can be realized by the omission of calculating the light-field distribution from those hidden-surfaces. On the other hand, the typical solution for synthesizing holographic 3D scenes with reciprocal occlusion is based on wave-optical consideration of field propagation. This method is generally referred to as silhouette masking. It is applicable not only to polygon CGH but also point cloud CGH. The simple omission process of hidden-triangular facets produces the coarse approximation of the occluded borders since some triangular facets need to be partially occluded. Erstwhile researches did not give consideration to the partial occlusion in the self and reciprocal occlusion culling.

In this paper, the representation technique of partial occlusion for phase-regularized polygon CGH [5] is addressed. We demonstrated the proposed method with numerically reconstructed results.

II. REPRESENTATION OF PARTIAL OCCLUSION

In Fig. 1, we illustrate the 3D target model composed of triangle facets and the background that also consists of triangles. The background is partly overlapped by two objects. If the wave field is acquired without consideration of this partial overlap, these objects are reconstructed as transparent phantom images.

To shield the light field distribution that should not be calculated, in preceding research, they divided the propagation process into a few steps. First, the background field is propagated from spatial light modulator (SLM) plane to object plane. After, the wave field of background is masked silhouette of the object in the object plane. Then, the masked background field and the object field are added, and propagated to the SLM plane [4]. But this approach raises a problem that we have previously touched on [5].

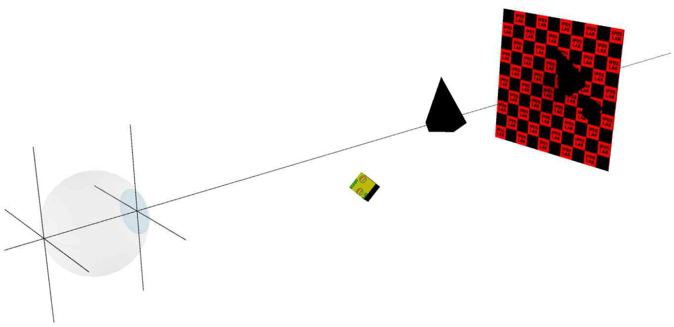

Figure 1. Synthesis and observation of holographic 3D scenes

For removing the dark-line defect [5], we clarified the physical origin of the defect and addressed the concept of phase-regularization, where the complex field is calculated in the retina plane, not the object space to solve phase mismatch problem. We show the numerical reconstruction image in Figs. 2(a) and 2(b). Silhouette masking process passed off sequentially in the retina plane.

The dark-line defect is eliminated, however, the interference at the edges between background and object is observed. In Figs. 2(c) and 2(d), we use silhouette masking technique in the SLM plane after phase-regularization, then the interference between the background and objects is removed.

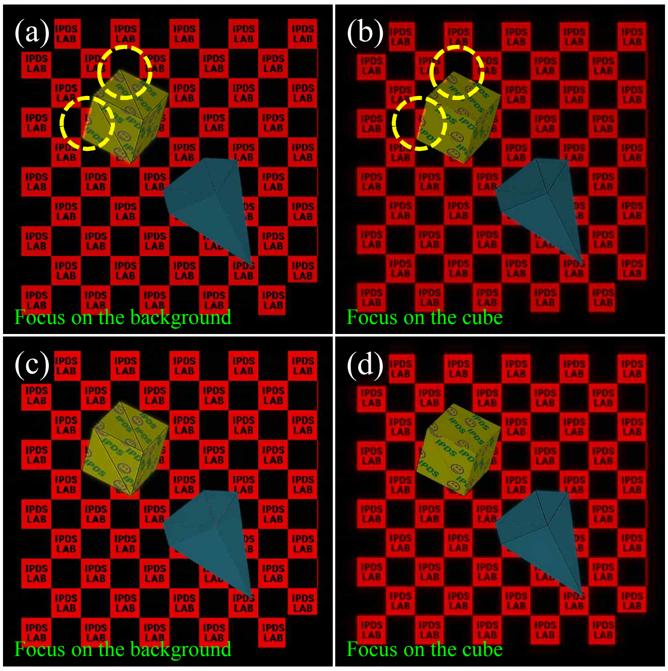

Figure 2. Numerically reconstructed images with the silhouette masking at (a)(b) the retina plane and (c)(d) the SLM planes.

III. CONCLUSION

In conclusion, we have investigated the representation technique of partial occlusion for phase-regularized polygon CGH. The proposed method provides clear holographic image without interference when the 3D model is defocused. If the silhouette masking process is enacted sequentially according to the depth information of object, we can construct more complete and general partial occlusion technique.

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