Phase regularization in polygon computer generated hologram synthesis

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***Abstract*—The phase mismatch problem in the conventional polygon computer generated hologram synthesis algorithm is addressed. To resolve the phase mismatch problem, the concept of the phase regularization in polygon computer generated hologram is devised and a novel synthesis algorithm of polygon computer generated hologram with phase regularization is proposed.**

Keywords-3D, hologram, computer generated hologram

I. INTRODUCTION

Holographic three-dimensional (3D) display is considered as ultimate 3D display and being actively researched nowadays [1]. However, there are several technological hurdles in limited pixel size of the spatial light modulators (SLMs) and huge computation resources required to generate holographic video contents to be resolved for realizing commercial holographic 3D displays. At present, most research effort is devoted to those fundamental problems. One of the important issue is the representation theory of computer generated holograms (CGHs). The objective of this research field is to synthesize CGH that can represent photorealistic holographic 3D objects and scenes. There have been several theoretical studies on the representation theory of CGH. In this paper, we would like to address the phase mismatch problem in the polygon CGH synthesis algorithm.

In general, CGH can be synthesized by the point cloud method and the polygon mesh method. The point cloud technique has been widely used to compute CGH of a 3D object. However, in the point cloud method, highly dense point cloud is required to correctly represent realistic objects and also a huge amount of computation resource is necessary [2].

On the other hand, the polygon CGH technique is advantageous relatively in that 3D objects are represented by the set of triangular facets, which is popular object representation method in the field of computer graphics. In the polygon CGH algorithm, the diffraction field by the triangular facet aperture illuminated by a carrier plane wave is the holographic 3D image light field of the triangular facet. Then the holographic 3D image light field is mathematically expressed by the angular spectrum integral [2].

To make CGH image as realistic as possible, several representation techniques are used such as texturing, shading and rendering. In the existing polygon mesh method, the dark line defects observed in the surface of the holographic 3D image between neighbor triangles is known as an unsolved problem. The polygon CGH model calculated by the conventional polygon CGH synthesis is shown in Fig. 1. The dark line defects can be observed on the surface of the 3D objects.

Figure 1. The dark borders in a 3D object calculated by the conventional polygon CGH

Realistic representation of 3D objects is the core in CGH algorithm, but these dark boundaries hinder that a 3D object looks like a real-world. In this paper, the method of removing the dark boundaries is proposed.

II. PHASE REGULARIZATION

The origin of the dark line defects is investigated. As shown in Fig. 1, the dark boundaries mean relatively lower energy. After light passes through the aperture, the diffraction of the incident carrier plane wave occurs at the polygon boundaries of polygon CGH due to the abrupt change in the wave front around the boundaries of adjacent triangle facets as shown in Fig. 2 (a).

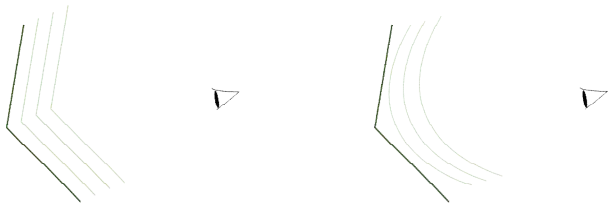

Figure 2. Wavefronts in (a) the conventional method (b) phase regularization

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The eyes of observer recognize the diffraction by the abrupt change in the wave front profile. To prevent the abrupt change in the wave front profile, the wave front needs to preserve the smoothness around the boundaries. Fig. 2 compares the wave front profiles of the holographic field generated by the conventional method and the proposed phase regularization technique.

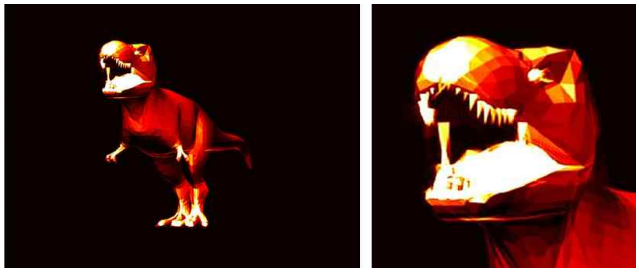

Figure 3. The 3D object generated by polygon CGH with phase regularization

In Fig. 3, the numerical result of the phase regularization is presented. In comparison of Fig. 3, it seems that dark line defects on the surfaces of 3D object were removed. Consequently, the proposed method can give us the effective method for representing the sleek surfaces.

III. CONCLUSION

In conclusion, the phase regularization technique of polygon CGH has been proposed. In practice, quite more polygons are necessary in order to a detailed description of 3D scenes. Removing the dark line defects by the proposed phase regularization would enable photorealistic representation of an object.

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