Line-defect removal in the fast-Fourier transfrom based synthesis of polygon computer-generated hologram

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***Abstract*—The line-defect problem is appeared because of the limited-period in the computation grid when we calculate the polygon computer-generated hologram (CGH) by the fast Fourier transform (FFT). To solve this problem, we propose the method that is accomplished by partially filtering the angular spectrum of the polygon consisting the 3D object. Through partially filtering the angular spectrum of intersection line, the line-defect removal optical reconstruction results of polygon CGH are presented.**

Keywords-componen: Holographic display, Polygon Computer Genarated Hologram, Fast-Fourier Transform.

I. INTRODUCTION

The holographic 3D display is considered as ultimate three-dimension (3D) display. The computer-generated hologram (CGH) synthesis is one of the most important technologies for the holographic 3D display. There are several ways to generate CGH, but we use the polygon CGH method that have the advantage of realistic and fast calculation time [1]. There are two calculation ways in the polygon CGH synthesis, the first way is analytic method and the second way is fast-Fourier transform method. The analytic method is that calculating polygon angular spectrum CGH by analytical Fourier transform formula in the angular spectrum domain. While, the FFT based method can be applied for textured polygon CGH, but the discrete calculation induces some numerical errors in the CGH calculation. As a consequence, when using the fast-Fourier transform method, we can see that line-defect problem occurs around the borders of adjacent triangular polygons [2]. In this paper, we analyze the cause of the line-defect defects and presents an effective filtering method for removing the line-defect.

II. ANALYSIS OF THE LINE-DEFECT PROBLEM.

Ideally, when we calculate the angular spectrum CGH of polygon by the analytic method, the exact angular spectrum of polygon facets can be obtained. However, in the FFT-based method, the discrete approximation of the continuous angular spectrum integral induces some numerical errors. A representative example is the line defect problem observed in the reconstructed holographic image as shown in Fig. 1(a). The angular spectrums of the sides of two adjacent polygons are overlapped in the shared border. Unlike the analytic method, the angular spectrum of normal direction that represents the border edges of polygon causes the line-defect since the phase mismatch of the angular spectrum s of two triangular facets. To resolve this problem, we propose a partial filtering method of the phase-mismatched angular spectrum components of the polygon object, where the phase-mismatched partial angular spectrum components of the borders of the two adjacent triangular facets is selectively filtered that should be removed when the two adjacent triangular is connected. Comparing Figs. 1(a)-1(c), we see that the proposed filtering method for the FFT-based CGH synthesis is effective in line defect removal and comparable to the analytic method. In Fig. 1(b), the line defect is clearly removed and all the line-defect is disappeared on the object surface.

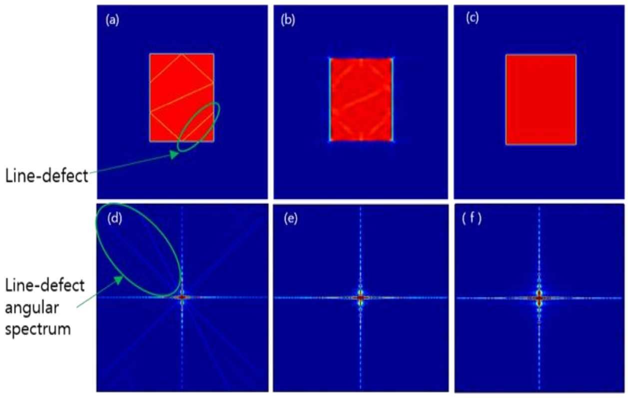

Figure 1. Reconstructed object by conventional method (a), its angular spectrum (d), reconstructed object by proposed method (b), its angular spectrum (e) and reconstructed object by analytic method (c), its angular spectrum (f).

III. PARTIAL LINE-DEFECT FILTERING METHOD

Generally, the reconstructed object by using the polygon CGH synthesis method is consisted of many light field elements of unit triangular facets. Each light field elements of unit triangular facets have own angular spectrum, and it has a particular shape that is consisted of three-lines along the perpendicular directions to all sides of the triangle as shown in Fig. 2.[3]

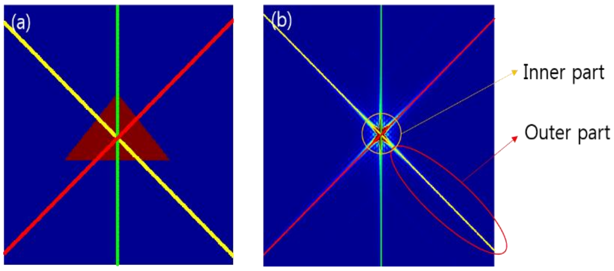

Figure 2. (a) A unit triangle facet in the local coordinate and (b) its angular spectrum profile

Angular spectrum of polygon can be divided into two parts, one is outer part and the other is inner part as shown in Fig. 2(b). The outer parts of angular spectrum have signal of each side of the triangle and inner parts that have low-frequency area have signal of inner facet of triangle.

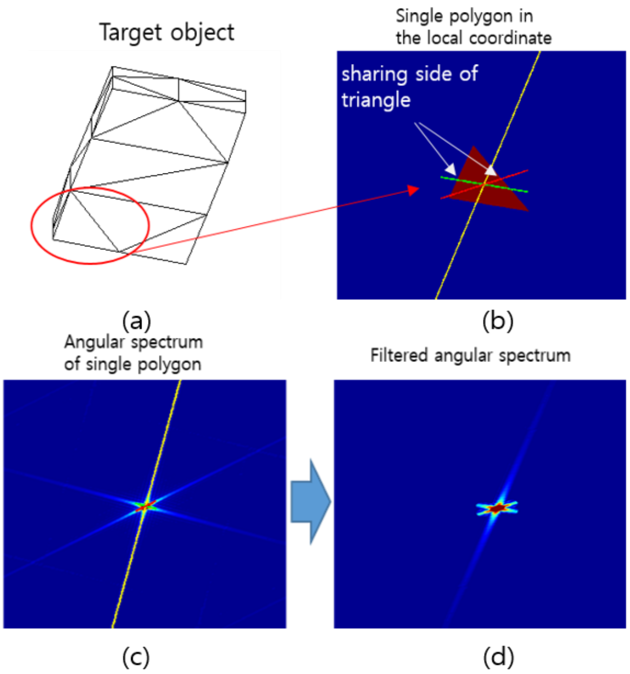

Figure 3. (a) The target object, (b) single polygon in the local coordinate, (c) angular spectrum of single polygon, (d) filtered angular spectrum

Our purpose is removing line defects, therefore, our region of interest (ROI) is an inner triangle facet except the shared edges of triangles while all outer angular spectrums (non-ROI) should be eliminated by filtering. The result of filtered angular spectrum is shown in Fig. 3. In Fig. 3(b), there are two shared edges of triangle. Thus, its angular spectrum is filtered along the direction of perpendicular of shared edges. In Fig. 3(d), we can observe filtered angular spectrum that only remain in the ROI.

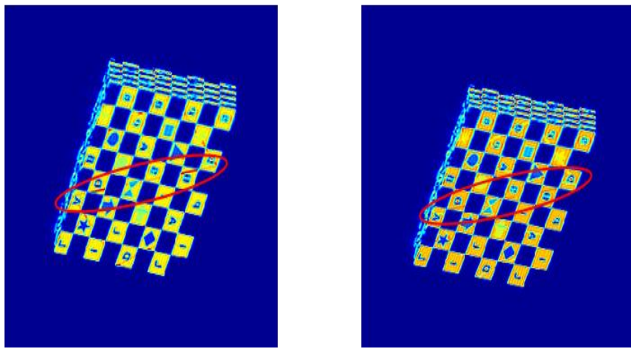

Figure 4. Reconstructed 3D object by (a) fast-Fourier transform and (b) the proposed method.

We observe the line-defect of the reconstructed image is removed clearly in Fig. 4. (b), but a little noise still is remained because of un-optimal filtering size. The size of remaining inner part of angular spectrum determines the quantity of signal of triangle inside facets. If we remain too much signal of low frequency, line-defect noise will be appeared. Therefore, suitable size of filtering is required. It is necessary to find the optimal size of filtering size.

IV. CONCLUSION

In this paper, we proposed a method to remove the line defect problem of the FFT-based polygon CGH synthesis by partially filtering the angular spectrum of the polygon units. When removing the non-ROI area of angular spectrum, the proper choice of size of remaining low-frequency area is important. If we remove the low-frequency area too much, that causes signal loss of inside of triangle facets. While, if we remain low-frequency area too much, that also cause remain noise of the sides of triangle. Finding optimal remaining area of low-frequency is our future work.

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