Efficient Computation of Binary-Weighted Computer-Generated Hologram for Gradation Representable Electroholography

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ABSTRACT

We proposed fast computation for the gradation representable electroholography using the bit planes comprising binary-weighted computer-generated hologram (CGH). We succeeded in reducing the duplicate CGH calculation of same object points. Consequently, the proposed method is 2.7 times faster than the previous method.

1 INTRODUCTION

Electroholography based on computer-generated hologram (CGH) is considered to potentially realize the ultimate three dimensional (3-D) television. However, the calculation of a CGH become enormous and has not yet been put into practical use. The accelerated CGH calculation is required for an electroholography to become practical [1-4].

We have already proposed a simple gradation representation method using binary-weighted CGHs (BW-CGHs) for an amplitude-modulation-type spatial light modulator (SLM) [5-6]. Moreover, we have proposed color electroholography using BW-CGHs [7]. Color electroholography using BW-CGHs can easily adjust the color of the reconstructed 3D images by changing the gradation value of the RGB areas of the RGB BW-CGHs without controlling the brightness of the reference light. Furthermore, we tried real-time gradation representable electroholography using BW-CGHs [8]. However, the calculation speed of BW-CGHs was not fast because same calculations were repeated several times in many object points of the 3Dobject.

In this article, we proposed efficient computation of the BW-CGHs used in the gradation representable electroholography.

2 GRADATION REPRESENTATION USING BW-GHs

In Fig.1, a, b and c shows the object points reconstructed from two BW-CGHs with different gray levels and the conventional binary CGH, respectively. Thus, the gray level of the BW-CGH can adjust the light intensity of the reconstructed object point.

Fig 2 shows an outline of the gradation representation

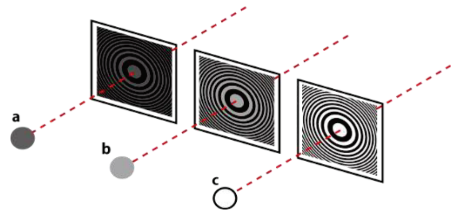

Fig. 1 Light intensities of the object points reconstructed from BW-CGHs

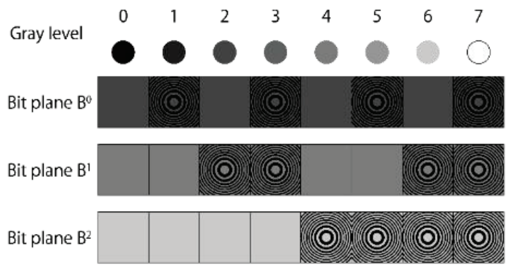

Fig. 2 Assignment of the object points of the 3D object to the bit planes consisting of BW-CGHs with different gray levels

using three BW-CGHs with different gray levels. These BW-CGHs are used as the multiple bit planes B^0, B^1, and B^2. The eight object points with gray levels ranging from zero to seven are assigned to the bit planes B^0, B^1, and B^2. Here, the m-th bit plane is described by B^m, and the object points reconstructed from the bit plane B^m have 2^m gray levels. Therefore, the reconstructed object points from the bit planes B^0, B^1, and B^2 have 2^0, 2^1, and 2^2 gray levels, respectively. When the bit planes B^0, B^1, and B^2 shown in Fig.2 are repeatedly displayed at high speed, the object points with gray levels ranging from zero to seven are reconstructed.

3 EFFICIENT COMPUTATION FOR GRADATION REPRESENTABLE ELECTROHOLGRAPHY

3.1 BW-CGH Calculations in Previous Works [5-7]

Fig. 3 shows the BW-CGH calculations for the multiple bit planes used in the previous works [5-7] when the 3D video with eight gradations is reconstructed. The respective object points (P1, P2, P3, …) on the original 3D object are assigned to the bit planes B^0, B^1, and B^2

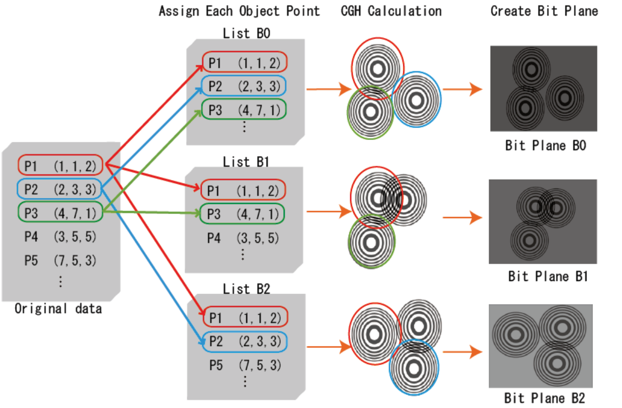

Fig. 3 CGH calculation used in previous works [5-7]

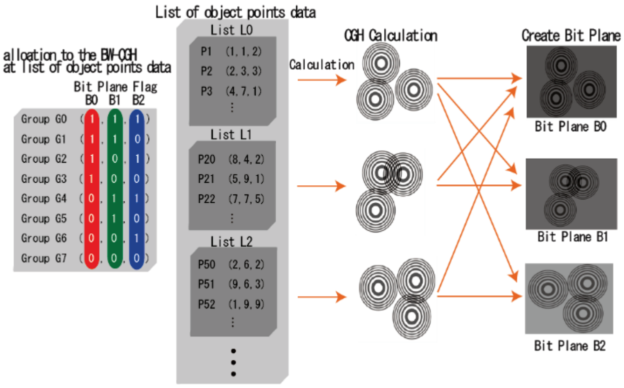

Fig. 4 Proposed method

according to the corresponding light intensities. In Fig. 3, Lists B0, B1 and B2 compose of the coordinate data of the object points assigned to the bit planes B^0, B^1, and B^2, respectively. The binary CGHs for the bit planes B^0, B^1 and B^2 are respectively calculated using the coordinate data of the Lists B0, B1 and B2, and the BW-CGHs for the bit planes B^0, B^1, and B^2 are respectively generated from the binary CGHs for the bit planes B^0, B^1 and B^2. However, in Fig. 3, the object point P1 is assigned to the bit planes B^0, B^1, and B^2. When the BW-CGHs corresponding to the bit planes B^0, B^1 and B^2 are generated, the same calculations for the object point P1 are performed three times. Thus, in previous work [5-7], same calculations are repeated several times in many object points of the 3Dobject.

3.2 Proposed method

Fig. 4 shows outline of the proposed method when the 3D video with eight gradations is reconstructed. In Fig. 4, the object points of the original 3D object data are assigned to eight groups to void the duplicate binary CGH calculation. The bit plane flags shown in Fig. 4 mean the bit planes to which the object points of the respective groups are assigned. The lists L0 to L7 are compose of the coordinate data of the object points of the groups G0 to G7, respectively. The CGH data calculated from the coordinate data of the respective lists is add to the CGH data for the respective bit planes that the bit plane flags are 1. Thus, the CGH data of the respective object points of the original 3D object is calculated only once.

Table 1 Calculate time using the proposed method and the previous method.

	Calculation time [ms]	
Object Points	Proposed method	previous method
4840	21.87	59.22

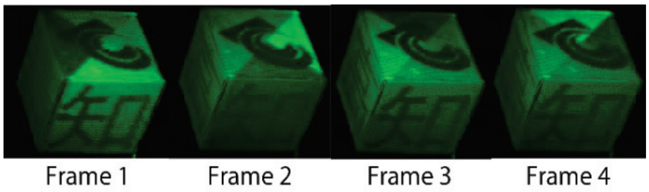

Fig.5 Snapshot of real-time movie of eight-gradation 3-D object

4 RESULTS AND DISCUSSION

We used NVIDIA GeForce GTX TITAN X, Intel Core i7 4770, CUDA 7.0 SDK, Linux (Cent OS 7.0), Open GL 4.5.0. The digital micromirror device (Texas Instruments DLP LightCrafter 6500) is also used as a SLM. The original 3D model consists of 4,840 object points and is expressed in eight gradations. The top side of the original 3D model is composed of 4 triangles, and the respective triangles have the different gradation values. Table 1 shows the calculation time using the proposed method and the method in the previous works [5-7]. Here, the resolution of BM-CGH is 1,920 × 1,024. The proposed method becomes 2.7 times faster than the calculation method used in previous works [5-7].

5 CONCLUSIONS

We proposed fast computation for the gradation representable electroholography using the bit planes comprising BW-CGHs. Consequently, the proposed method is 2.7 times faster than the calculation method used in previous works [5-7].

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