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Comparison of computation time and image quality between CGHs calculated by the point cloud and polygon-based method

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1. Introduction

The point-based method or point cloud is commonly used for calculating object fields and fringes of computer-generated holograms (CGH). However, many high-definition CGHs such as the "The Venus" were created by using the polygon-based method [1]. This was because the point cloud was generally too time-consuming to calculate high-definition CGHs that are commonly composed of billions and sometimes ten billion pixels. Computation by the polygon-based method is most likely faster than that by the point cloud. However, it is not actually confirmed by comparison how fast the polygon-based method is. In addition, the reconstructed surfaces look noisy in the polygon-based method because it uses random phase in order to diffuse light emitted by a polygonal surface. Therefore, there is a great interest in a comparison of computation time and image quality between the polygon-based method and point cloud.

These comparisons were difficult before because of slowness of point cloud. It was even impossible to create high-definition CGHs by point cloud. Recently, however, GPUs allow us to generate CGHs by point cloud much faster [2]. In this paper, we measure computation time of object fields for quasi high-definition CGHs with the same 3D scene by using the point cloud with GPU and the polygon-based method. Additionally, we actually fabricate these CGHs and compare the optical reconstruction to verify the quality.

2. Methods for comparison

The 3D scenes used for the comparison are shown in Fig. 1. Here, binary images are mapped on the models as the texture. An important issue of the comparison is how to make it fair. Since two methods are very different in the principle, they have much different parameters such as the number of point sources and polygons. The number of point sources especially affects the computation time and image quality of CGHs by point cloud. Therefore, we adopt the parameter based the human vision. Angular resolution of human eyes is 1/60 degree in average persons. Thus, suppose that viewers see the CGH 250 mm apart from the CGH, we adopted the linear density of point sources of 9.84 mm^{-1}.

Other parameters used for creating the CGHs are summarized in Table 1. The parameters of PCs and software used for calculation are also shown in Table 2. Here, note that one of the newest GPU is used for calculation by point cloud, whereas an existing PC and software are used for that in the polygon-based method.

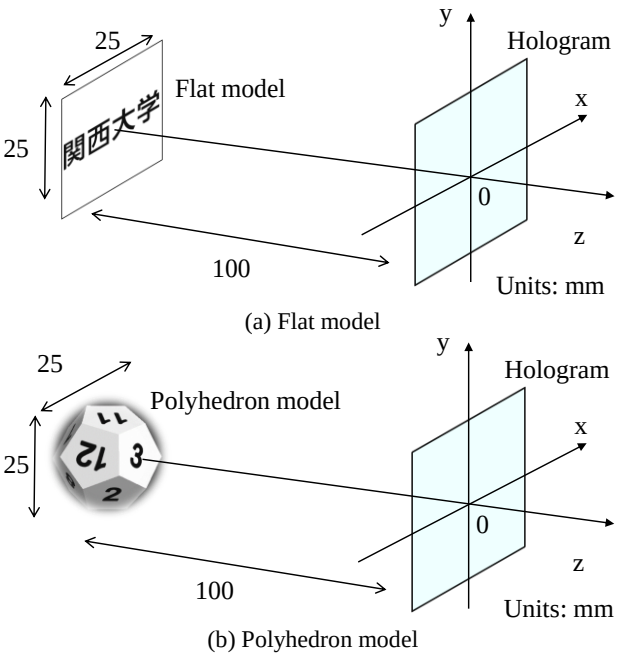

Fig.1 3D scenes of the test CGHs.

Table 1 Parameters of the test CGHs.

Number of pixels	32,768 × 32,768	
Pixel pitches	0.8 μm × 0.8 μm	
Design wavelength	632.8 nm	
Model	Flat	Polyhedron
Number of point sources (Point cloud)	60516	80962
Number of polygons (Polygon-based method)	200	72

Table 2 Parameters of PCs used for calculation.

PC1 (polygon-based method)	
CPU	Intel Xeon E5-2690 v2 (3.00 GHz)
Main memory	512 GB
Number of real cores	20
Software*	MKL 11.2/WFL 3.3.2/PSL 1.5
PC2 (point cloud)	
GPU	NVIDIA GeForce GTX TITAN X (1.08 GHz)
Global memory	12 GB
Number of CUDA cores	3072
Software	CUDA 7.5
Host CPU	Intel Core i7-5930K (3.50 GHz)

* WFL/PSL are software library distributed in our site.

3. Results of comparison

The computation time and pictures of optical reconstruction by coherent light are shown in Fig.2 and Fig.3, respectively. These show calculation by combination of point cloud and GPU is faster than that by CPU and the polygon-based method in the 3D model, but the flat model gives an opposite result; the polygon-based method with CPU is still faster than point cloud. As for image quality, we cannot find considerable differences between these CGHs at a glance.

4. Conclusion

The computation time and image quality of CGHs calculated by using point cloud with GPU were compared with that by the polygon-based method with CPU.

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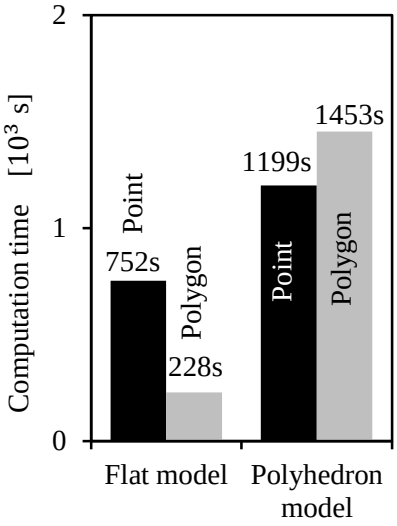

Fig. 3 Measured computation time.

References

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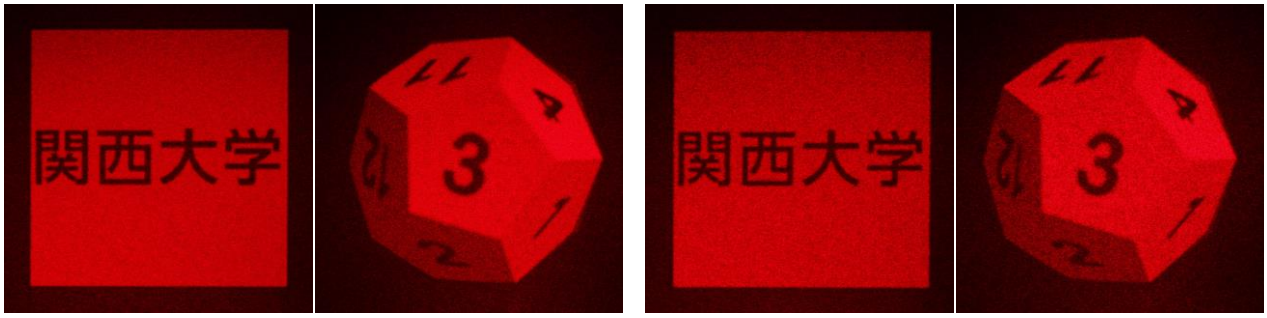

(a) Point cloud (b) Polygon-based method

Fig. 2 Pictures of optical reconstruction of CGHs calculated by using (a) point cloud and (b) the polygon based method.