Cost-effective Portable Holographic Projector using a Single Board Computer

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ABSTRACT

We proposed cost-effective portable holographic projector composed of a portable digital micromirror device board and a single board computer. Consequently, the proposed projector succeeded to project the reconstructed video at 60 fps.

1 INTRODUCTION

Electroholography using computer-generated hologram (CGH) is expected to become the ultimate 3D television (TV). Real-time electroholography is indispensable to realize 3D TV. However, the calculation amount of CGH is enormous. Real-time electroholography requires high-performance computational power. For the practical use of real-time electro-holography, the study of the accelerated CGH is very important [1]. A graphics processing unit (GPU) has high-performance floating-point calculations at low cost. 3D real-time electroholography using multi-GPU clusters has been reported [2,3], but the system is large.

Holographic projection based on electroholography has been reported [4,5]. The holographic projector can be projected 3D image on 3D screen without using lens. However, spatial light modulator to display CGH is very expensive. If holographic projector is portable, it can be carried to various places and project 3D image on 3D screen or 3D object.

In the article, we proposed the cost-effective portable holographic projector composed of a portable digital micromirror device (DMD) projector and a single board computer.

2 CGH COMPUTATION

We adopt a simple algorithm to calculate an in-line hologram (Fig.1). For a 3D object composed of N_p points, the light intensity of a point on the hologram is calculated by the following equation.

$$I(x_\alpha, y_\alpha) = \sum_{j=1}^{N_p} A_j \cos\left[\frac{\pi}{\lambda z_i}\left\{\left(x_\alpha - x_j\right)^2 + \left(y_\alpha - y_j\right)^2\right\}\right], \quad (1)$$

where I (x_a, y_a, 0) is the light intensity at the pixel position (x_a, y_a, 0) on the hologram. (x_j, y_j, z_j) indicates the

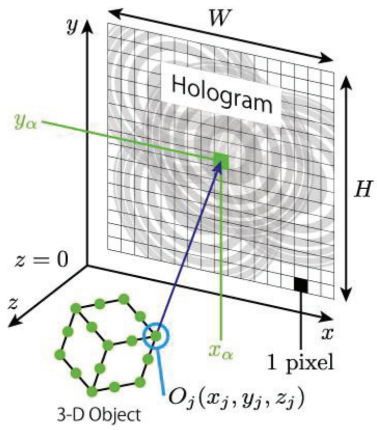

Fig. 1 CGH coordinate system

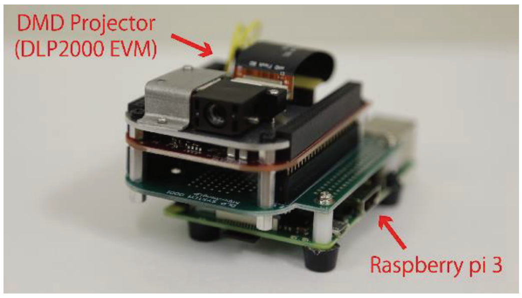

Fig. 2 Proposed portable holographic projector

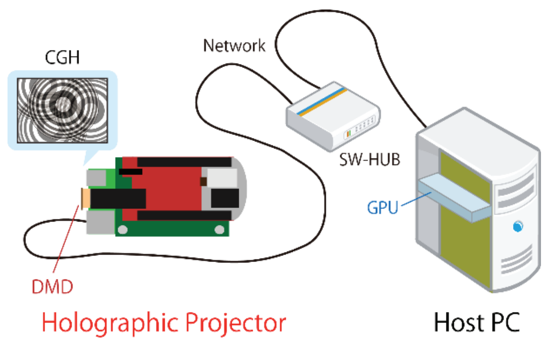

Fig. 3 Proposed system

coordinates of the j-th object point on the 3-D object. λ is the wavelength of the reconstructing light If the CGH resolution is $H \times W$, the computational complexity of CGH calculation is O (N_pHW). Therefore, the amount of CGH calculation becomes enormous.

3 PROPOSED SYSTEM

Fig.2 shows the proposed portable holographic projector composed of a single board computer and the portable DMD projector. We used Raspberry pi 3 model B+ and TEXAS INSTRUMENTS DLP LightCrafter Display 2000 Evaluation Module (DLP 2000 EVM) as a single board computer and a portable DMD projector, respectively. The size of the proposed holographic projector is 10.2 cm ×6.5 cm ×5.3 cm.

Fig.3 shows the proposed system to project real-time reconstructed video using the holographic projector. A single board computer is connected to host computer via gigabit ethernet. In host computer, a GPU calculates the CGH and packs the CGH [3]. Host computer send the packed CGH data to a single board computer in the holographic projector. The single board computer unpacked the packed CGH data and display the CGH on DMD. Here, we used Raspbian Buster with desktop as operating system and OpenGL 3.1. The unpacking CGH process was performed by the code written in OpenGL Shading Language.

4 RESULT

Fig.4 shows the optical system. We used green laser (532 nm) as a light source. The emitted light from green laser is converted into parallel light by an objective lens and a collimator lens. The parallel light is used as the reconstructed light.

In host computer, we used Intel Core i7 7800 X and NVIDIA GeForce GTX 1080 Ti as a CPU and GPU, respectively.

Fig.5 shows the projected 3D image on cubic screen using the proposed system. The 3D image comprises 4,840 points. The cubic screen on a side 8 cm is used. The Fig. 6 shows the snapshots of projected reconstructed video “Tyranno” on a plane screen. “Tyranno” comprises 11,646 points. In Figs. 5 and 6, the resolution of CGH is 854 ×480. The reconstructed video is projected on plane screen at 60 fps.

5 CONCLUSIONS

We proposed the cost-effective portable holographic projector. Consequently, the proposed projector succeeded to project the reconstructed video at 60 fps.

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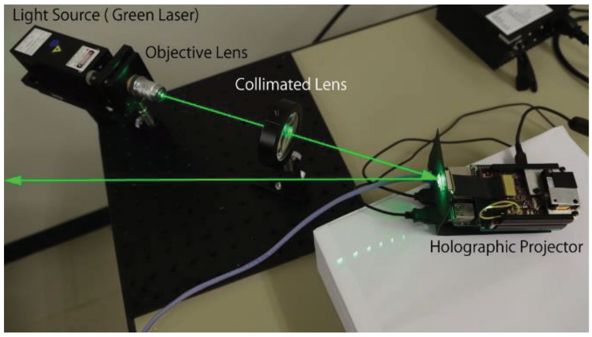

Fig. 4 Optical system

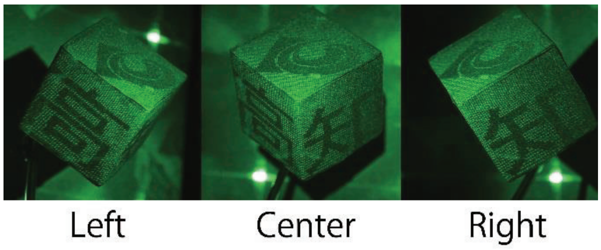

Fig. 5 Projected 3D image on the cubic screen

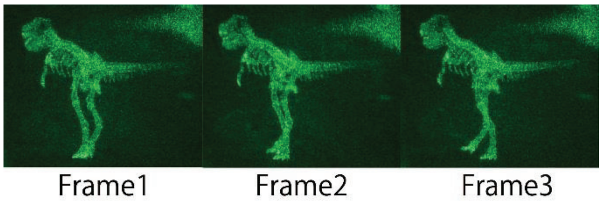

Fig. 6 Snapshots of projected reconstructed video

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