Holographic Projection System for Drawing Fingertip Trajectory Obtained from Depth Camera

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ABSTRACT

We proposed to the interactive holographic projection system for drawing the trajectory of fingertip on 3D object. The proposed system can project the trajectory of fingertip obtained using the depth camera at 90 fps.

1 INTRODUCTION

Holography satisfies all the physiological factors for stereoscopic vision. Electroholography based computer-generated hologram is expected to be an ultimate 3-D display technology. However, the real-time calculation is not easy because the calculation amount of CGH is enormous. In recent years, the floating-point arithmetic and cost performance of GPU have been remarkably improved. 3D real-time electroholography using multi-GPU clusters has been reported [1,2]. We consider that the 3D real-time electroholography using multi-GPU clusters will be very useful for various 3D applications in future.

While, holographic projection based on electro-holography has been reported [3,4]. The holographic projector can be projected to multiple 3D objects, which have various shapes and are placed at various distance, without using lens.

Projectors are often used for discussions. Then you'll point at things with your fingertips. A depth camera can be track of fingertip. In using the real-time holographic projection, the trajectory of fingertip can be projected on various 3D object.

In this article, we proposed the interactive holographic projection system for drawing the trajectory of fingertip obtained using a depth camera.

2 CGH CALCULATION

Fig. 1 shows a coordinate system in a computer-generated hologram. We used a simple algorithm to calculate an in-line hologram from the point cloud 3-D model. For a point cloud 3-D model comprising of N_p object points, the light intensity of each pixel on CGH is calculated by the following equation:

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

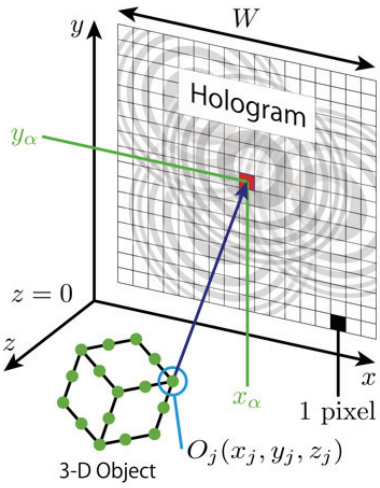

Fig. 1 CGH coordinate system

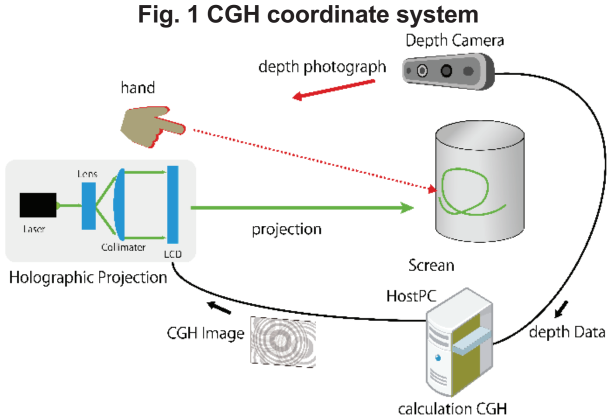

Fig. 2 Proposed system

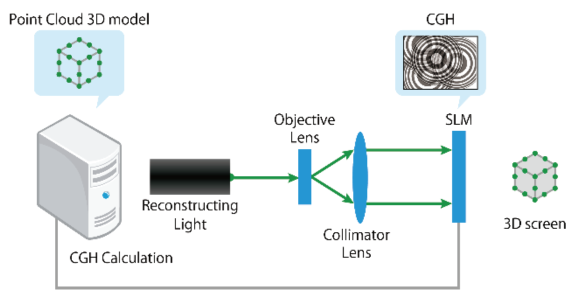

Fig. 3 Holographic Projector

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 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 ($N_p HW$). Therefore, the amount of CGH calculation becomes enormous.

3 IMPLEMENTATION

As shown in Fig. 2, this system is composed of a holographic projector, a depth camera for measuring depth, and a host PC to control them.

Fig. 3 shows an electroholography system used for projection. When the reconstructing light such as a laser is incident to the CGH displayed on a spatial light modulator (SLM), the reconstructed 3D image can project on the 3D screen.

Fig. 4 shows the flow chart of the proposed system. The depth data gotten from depth camera is sent to host computer, and the coordinate data of the fingertip obtained from the depth data is sent to a GPU. A GPU calculate the CGH using the coordinate data of the fingertip and display the CGH. As shown in Fig. 5, the trajectory of fingertip display is projected on a screen. Here, the holographic projector can display on 3D object.

4 RESULTS

We used NVIDIA GeForce GTX 680, Intel Core i5-8400, CUDA 10.0 SDK, Linux (Ubuntu 18.04.3 LTS), Open GL 4.5.0, Realsense2 2.25.0 SDK. Epson Inc. EMP-TW1000, and Intel RealSence Depth Camera D435 are also used as a SLM and the depth camera, respectively. We projected the trajectory of fingertip on two screens located at the different distances. Fig. 6 (a) shows the trajectory coordinate data of the fingertip obtained from the depth camera. Fig. 6 (b) shows the image of the trajectory projected on the screen located 2.5 m away from a SLM. Fig. 6 (c) shows the image of the trajectory projected on the screen located 2.0 m away from a SLM. Figs. 6 (a) and (b) respectively show the projected images focused on the screens by camera. In actually, the trajectory of fingertip is simultaneously projected on the two screens, and the projected images are focused on the respective screen. The trajectory of fingertip obtained using the depth camera projected at 90 fps.

5 CONCLUSION

We realized the interactive holographic projection system for drawing the trajectory of fingertip obtained using a depth camera. The trajectory of fingertip projected at 60 fps.

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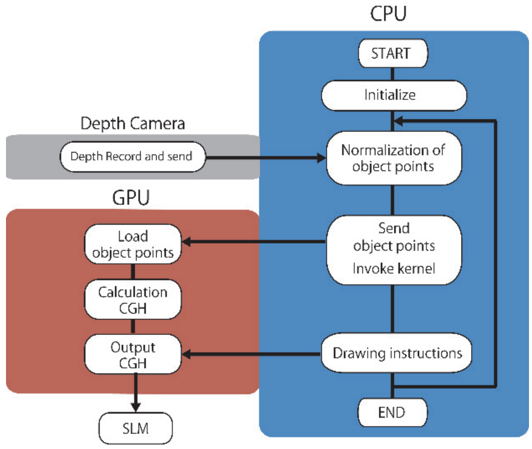


Fig. 4 Flowchart of the proposed method

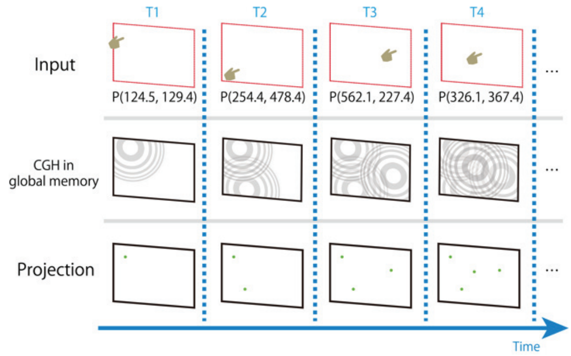
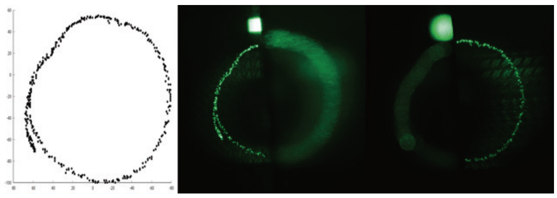


Fig. 5 Display of the trajectory of fingertip using the proposed method



(a) (b) (c)

Fig. 6 Projection using the proposed method

REFERENCES

[1] H. Niwase, et al., "Real-time electroholography using a multiple-graphics processing unit cluster system with a single spatial light modulator and the InfiniBand network," Optical Engineering, Vol. 55, Issue 9, 093108 (2016).

[2] H. Sannomiya, et al., "Real-Time Electro-holography Using Multiple GPU Cluster System with a Single Spatial Light Modulator and Gigabit Ethernet Network," Proc. of IDW'17, 3Dp1-19L, pp.922-923, 2017.

[3] E. Buckley, “Holographic laser projection,” J. Display Technol. 99, 1–6, 2010.

[4] T. Shimobaba, et al., "Lensless zoomable holographic projection using scaled Fresnel diffraction," Opt. Express 21, 25285-25290, 2013.