Retinal HDR: HDR Image Projection Method onto Retina

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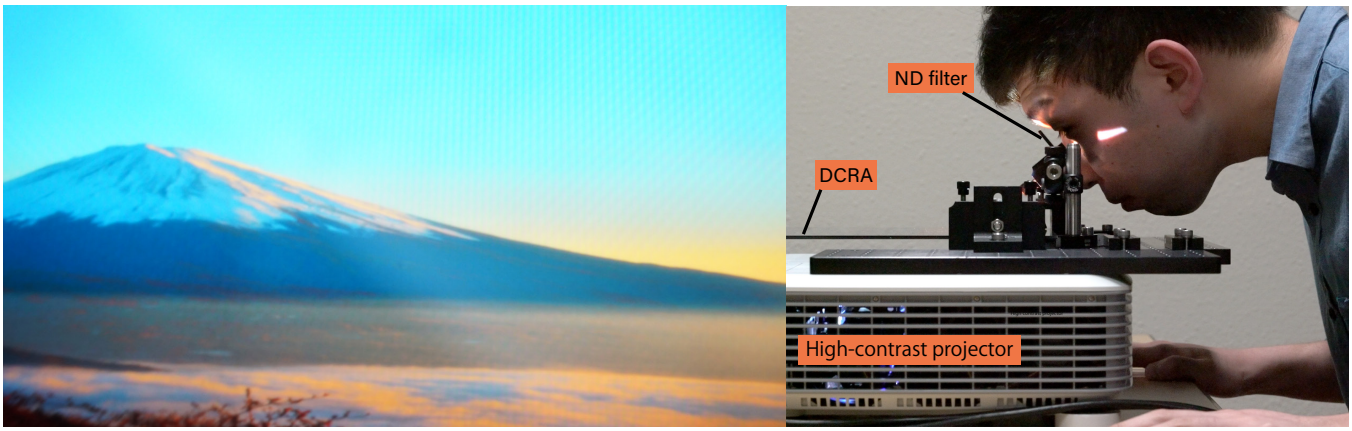

Figure 1: LEFT: Display image obtained our HDR image retinal projection system. RIGHT: Our prototype with HDR projector (Optoma EH320UST).

CCS CONCEPTS

• **Hardware → Communication hardware, interfaces and storage**;

KEYWORDS

Near-eye Display, High Dynamic Range (HDR), Retinal Projection

ACM Reference format:
Yuta Itoh, Kenta Yamamoto, and Yoichi Ochiai. 2018. Retinal HDR: HDR Image Projection Method onto Retina. In *Proceedings of SA '18 Posters, Tokyo, Japan, December 04-07, 2018,* 2 pages.
https://doi.org/10.1145/3283289.3283329

1 INTRODUCTION

The dynamic range of display is much lower than the one perceived by human eye. This problem has been studied in both aspects of photography and display [Debevec and Malik 1997; Hirsch et al. 2014].
There are multiple problems in the area of near-eye display: field of view, vergence-accommodation conflict, image quality, and dynamic range. A study has been conducted to solve such problems. High dynamic range (HDR) near-eye display is necessary for immersive experiences. However, compared with other near-eye display tasks, a few studies have targeted HDR near-eye display [Xu and Hua 2017]. In this paper, we propose HDR representation method for near-eye display combining Dihedral Corner Reflector Array (DCRA)-based retinal projection and a high-contrast projector. A DCRA is a commercially available optical element[1] which consists of numerous micro-mirrors as shown in Fig.2. A DCRA has been used for aerial imaging systems and aerial interactions. In recent years, a DCRA has been used as an optical element of near-eye display [Ochiai et al. 2018; Otao et al. 2018].
Our propose method has several advantage:

- We presented a near-eye display reproducing HDR images by combining a DCRA-based retinal projection system and a high-contrast projector,.
- We described the detailed configuration and implemented a prototype of our proposed method. Subsequently, we conducted an experiment to measure the performance of the prototype. Finally, we discussed the limitations and advantages of the proposed method.

2 IMPLEMENTATION

To demonstrate our proposed method, we build a prototype with a simple configuration by combining a HDR projector and a DCRA based retinal projection system as shown in Fig.1 RIGHT. Regarding retinal projection, as with [Ochiai et al. 2018], we build the optical circuit as shown in Fig.2 (c). We used Optoma EH320UST[2] as the projector, which has contrast ratio of 20000:1. As light that originally should be projected on the wall surface is focused by DCRA, it is too bright to set the eye directly on the imaging plane and view the image. Therefore, we must place an absorption-type Neutral Density (ND) filter in front of the eye position to reduce brightness.

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[1] https://aska3d.com/en/ (last accessed Oct 22nd, 2018)
[2] https://www.optoma.com/us/product/eh320ust/ (last accessed Oct 22nd, 2018)

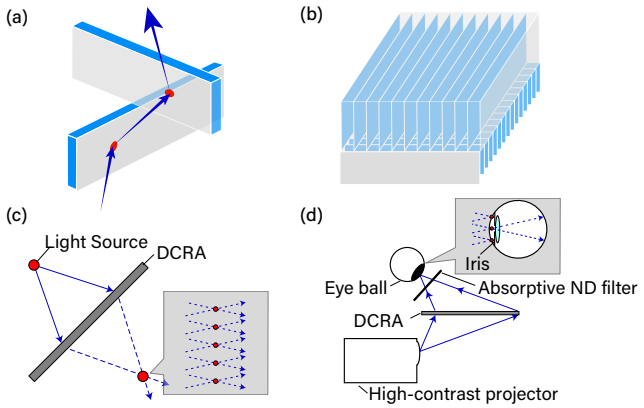

Figure 2: Principle of DCRA and DCRA-based retinal projection. (a), (b) Structure of DCRA using a micro-mirror array. (c) Simple schematics show that the DCRA transfers the real image to the plane symmetric position and generates numerous focas point. (d) Discipline of DCRA-based retinal projection system. A part of the multiple light sources transferred by DCRA projects the image onto the retina through the center of the eye.

We used an absorptive ND filter with the optical density of 4.0. This ND filter reduces the light to 0.01%.

3 EXPERIMENT

The captured image is shown in Fig.3. To measure the perfomance of our prototype, we placed a camera at the eyeball position in Fig.2 (d). Sony α7R II was used as the camera. The ISO sensitivity was fixed at 250, and the F value was fixed at 3.5. The shutter speed was changed from 1/20 s to 1/1000 s.

4 DISCUSSION

In this study, we used DCRA consisting of a micro-mirror of pitch 0.5mm. The lattices observed in the captured image are generated by the DCRA. However, upon reducing the pitch size, the lattices will not be visible and the resolution will increase. The resolution of the image projected onto the retina depends on the pitch size of the DCRA and the resolution of the projector. Furthermore, the contrast of the image displayed using DCRA-based retinal projection depends on the projector used as shown in Fig.4. Thus, it is possible to increase the contrast ratio of the displayed image by increasing the contrast ratio of the projector.

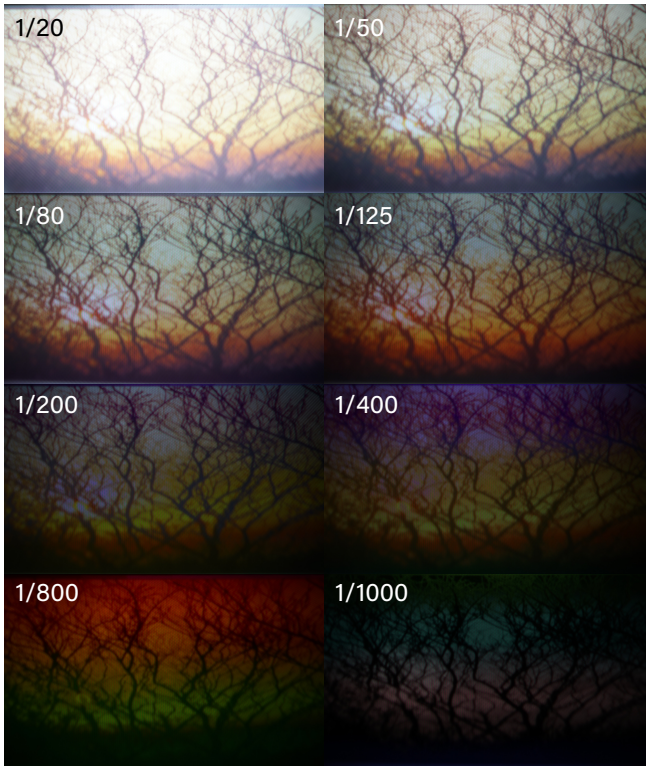

Figure 3: Images captured with the camera placed at the eyeball position in the retinal projection optical system Fig.2 (d). We displayed backlight photo.

Figure 4: Comparison of projected images using our system. LEFT: Using Optoma EH320UST with the contrast ratio of 20000:1. RIGHT: Using EPSON EB-1775W with the contrast ratio of 2000:1.

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