Aerial Image on Retroreflective Particles

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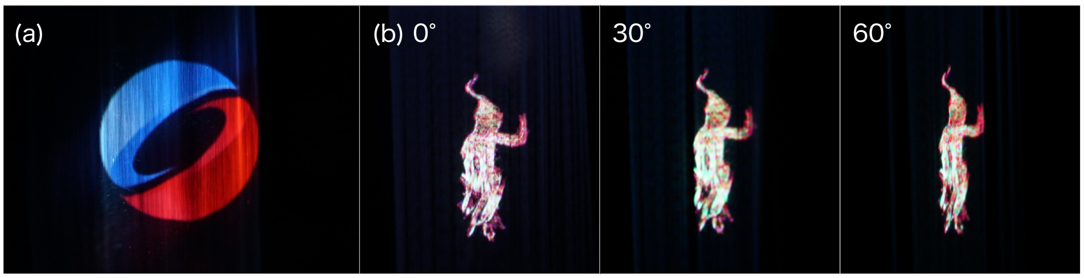

Figure 1: (a) Image of SIGGRAPH logo projected on our proposed screen. (b) Images of fire (We took the same image at 0°, 30° **and** 60°**.**

CCS CONCEPTS

• **Hardware → Displays and imagers**;

KEYWORDS

Passive display, Projection, Retroreflection, Aerial screen

ACM Reference format:
Shinnosuke Ando, Kazuki Otao, Kazuki Takazawa, Yusuke Tanemura, and Yoichi Ochiai. 2017. Aerial Image on Retroreflective Particles. In *Proceedings of SA '17 Posters, Bangkok, Thailand, November 27-30, 2017,* 2 pages. https://doi.org/10.1145/3145690.3145730

1 INTRODUCTION

Many kinds of methods can be used to render aerial images. Among these, fog screens[Rakkolainen et al. 2005] have been used as primary diffusers of passive aerial display. In this type of display systems, diffusers are generated by the fog generator, and the projector projects images onto the fog. However, there are some issues to be considered. The first problem is that the equipment is large and heavy. The second is that the screen is not stable because of low wind tolerance. Aerosol-based screens[Suzuki et al. 2017] can resist the wind and exhibit a high portability. However, there are limits on the size and the time to project.

We propose a new method of rendering aerial images using retroreflective particles. Owing to the properties of the retroreflective material, it is possible to place the projector in the same direction as the observer with respect to the screen. This has an advantage that the image can be observed without facing the light source. In addition, each particle is heavy enough to fall vertically due to gravity and there is no limit on the size in this method.

2 SYSTEM OVERVIEW

Figure 2 (a) shows the system overview of our proposed display. This system consists of retroreflective particles, a device to control the fall of retroreflective particles, and the laser projector. We drop retroreflective particles from the control device, and project aerial images from the observer's side.

Retroreflective particles consists of glass beads and reflective films. Glass beads are coated with reflective films. By coating reflective films, the light from the laser projector is reflected straight back along the same path from which it came when we drop retroreflective particles from the control device. When we drop retroreflective particles, retroreflective particles fall in various orientation. Therefore the incident light collides directly with the reflective film without passing through the glass beads according to a prescribed probability. Then the incident light scatters.

Figure 2 (b) shows the system about the control device. By using the stepper motor, it is possible to control the width of the slit. This device can be controlled in $1mm$.

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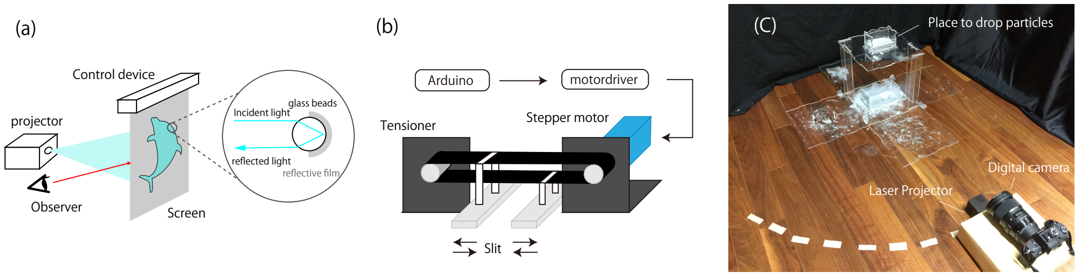

Figure 2: (a) System overview. (b) Control device. (c) Structure of experiment to measure maximum luminance.

3 EVALUATION

3.1 Brightness

We measure the light amount of the display and calculate the ratio of the light amount from the laser projector to the light amount from the display. Assuming that the light amount from the projector is B_b and the light amount from the display is B_d, the light amount ratio R is given by the following formula.

$$R = \frac{B_d}{B_b} \tag{1}$$

We use an optical sensor to measure the light amount. When we measure the light amount, we place the optical sensor at the position where the image is projected during the fall of retroreflective particles. As a result, the ratio of the light amount is as follows.

$$R = \frac{697}{995} = 0.700502... \tag{2}$$

From the above calculations, the light amount observable by the display is 70.050% of the light amount from the laser projector.

3.2 View Angle

We measure the maximum luminance of each angle and identify the viewing angle of the proposed display. We project an image of a white point from the laser projector and take a picture of the aerial image while changing the angle formed by the projector optical axis and the line of sight of the observer. (Figure 3) For the luminance measurement, we use a digital camera(α7s-2 SONY). We fix to ISO 4000, F 3.2 and choose the pixel with the maximum luminance of each image. Luminance is measured by the following formula. L(luminance) is the sum of each value about RGB (0 to 255).

$$L = 0.298912 \times r + 0.586611 \times g + 0.114478 \times b \tag{3}$$

The result are shown in Table 1 and Figure 3. It is observed that the maximum luminance decreases as the angle decreases. However, it is true that the viewing angle of our proposed display is wider than that of the fog display[Yagi et al. 2012]. Although the viewing angle of Pixie Dust[Ochiai et al. 2014] is wider than that of the proposed method, the resolution of this method is higher than that of Pixie Dust because the size of retroreflective particles is smaller.

Table 1: View angle of our proposed display

angle[deg]	0	7.5	15	22.5	30
luminance[L]	249	233.7	215.5	205.5	195.8
	37.5	45	52.5	60	
	180.3	146.5	166	134.6	

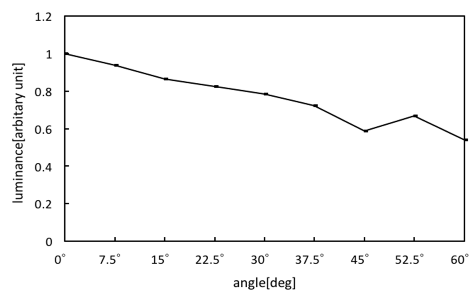

Figure 3: View angle of our proposed display

4 DISCUSSION

It is dangerous if observers inhale/swallow retroreflective particles via nose/mouse. We are considering establishing safety controls the screen.

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