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Auto-stereoscopic Projection System Using Retroreflective Sheet as the Screen

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Abstract- Auto-stereoscopic systems can be roughly divided into two types: projection type and non-projection type. The projection type is a system in which that left and right images are projected on a screen by a projector or projectors and requires special glasses to be worn in most cases. The non-projection type is based on a flat panel display such as an LCD. Systems in which auto-stereoscopic vision is possible are already widely used, e.g., parallax barriers or lenticular systems. In this study, we propose a new auto-stereoscopic projection system using a retroreflective sheet as a screen and have constructed an experimental system setup. This system enables stereoscopic view without the need for special glasses. We also discuss the conditions and design guidelines for where the projectors should be set to recognize the projected images as a stereoscopic image.

Keywords: Auto-stereoscopic projection system, Retroreflective sheet, No needs of glasses, Optimized arangement.

1. Introduction

Various stereoscopic displays for binocular parallax have already been proposed and some of them are currently in practical use. See (Takanori Okoshi 2011) for example. These displays are classified into two categories: projection type and non-projection type. In almost all of the projection type stereoscopic displays, special glasses are necessary to separate the left and right images. These glasses can be either active or passive. In an active system, a shutter is used to show the left and right images alternatively. This shutter system needs to be synchronized to the images projected on the screen.

In an anaglyph system, which is a passive system, red and blue glasses are required to separate the red and blue images projected on the screen. Another passive system is the polarization projection system, which needs two projectors that each project images through a polarized filters of which directions are perpendicular each other, and a “silver screen” that reflects polarized light without changing its polarized phase. In this system, the observer needs to wear glasses with polarized filters.

In this paper, we propose a new stereoscopic system that does not require items such as glasses to see stereoscopic images. The key element of this system is the use of a retroreflective sheet as the screen. A similar system using a retroreflective sheet as the screen has been proposed by (Yoshida, et al. 2010), which uses LED projector arrays, while our system uses only two small projectors.

2. Principle of the System

Fig. 1 shows a diagram of the proposed projection system. We use a retroreflective sheet as the screen. Retroreflective materials reflect almost all the entrance light to the entrance direction(Japanese Standards Association 2012).

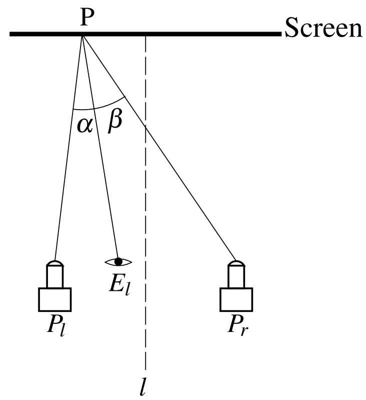

Fig. 1. Setup of stereoscopic projection system.

The symbols P_l and P_r are projectors that display the left and right images, respectively. The point P is a point on the screen and E_l is the left eye of the observer. For simplicity, the right eye of the observer is omitted in this figure. The angles α and β are the angles of reflected lights from the left and right projectors, respectively.

If α is small enough for the retroreflective sheet to reflect the left projector's light strongly and β is large enough for the retroreflective sheet to reflect the right projector's light weakly, the left eye of the observer perceives almost only the left image. Similarly, the right eye of the observer perceives almost only the left image. Hence, the observer sees a stereoscopic image.

3. Retroreflective Material and its Properties

3.1. The Retroreflective Sheet Used in the Projection System

There are several types of retroreflective materials. The one we used in our system is Ref-Lite#9301(Web-1), a so-called Type I, in which illuminant light is transmitted through the surface film(top layer), glass beads, and a binder layer to reach the reflecting layer. (For detail, see (Japanese Standards Association 2012, p.7).) Table 1 lists the retroreflection coefficients of the standard and Ref-Lite #9301, which are open lens type silver reflective materials consisting of million high index microscopic glass beads. Therefore, we only quote the values of Type I in the standard. [1]

Table 1. Retroreflective coefficients of the standard and material used in this research.

Observation angle	Entrance angle	Standard	Ref-Lite #9301
0.2°	5°	70	660.30
	30°	30	643.61
0.33°	5°	50	414.53
	30°	24	399.99
2.0°	5°	5.0	10.01
	30°	2.5	10.11

This table shows that retroreflectivity does not depend on the entrance angle. We therefor ignore the entrance angle condition.

[1] We were informed of the values for REF-LITE 9501 by the reseller, who asked the maker.

4. Design of the System

We estimate the optimal arrangement for the positions of projectors and the screen to percieve stereoscopic images.

4.1. Conditions and Determination of the Distances between Projectors and Screen

Let l be a perpendicular line of the screen across its center. Now, we put the projectors at the distances d from the screen and r from the line l, as in Fig. 1. The observer stays at the distance between the projectors and the screen. Let x be a distance between the point P and the center of the screen. We denote the pupillary distance as $2p$.

The angle α takes maximum values $\alpha_{\max} = 2\tan^{-1}\frac{r-p}{2d}$ at $x = \frac{r+p}{2}$, because the triangle $\mathrm{PP_lE_l}$ is isosceles when α takes maximum. The value $\alpha_{\max}$ is less than the angle that the reflection light is bright because the rays that come from the left projector are recognized by the left eye of the observer. Since the typical pupillary distance for adults is around 50–75 mm(Dodgson 2004), we set $p = 31.5$ mm. Since we set the observation angle of the left eye to less than around 1° by the property of REF-LITE #9301, we can set the projectors between 250 cm and 300 cm from the screen and between 6cm and 8cm from the line l.

4.2. The Properties of the Projectors Used in our System

From the previous discussion, we know that the distance between the projectors is not so wide. Therefore, we need to choose very small projectors and set them to be vertical since the width of the projectors is much longer than their height in almost all models. The model of projector which we selected is Panasonic Mini Viewer LF-PJ525H(Panasonic Co.,Ltd 2013).

- The dimensions are 102(W) $\times$ 60(D) $\times$ 22(H) mm.
- The angle of the projection is offset 100%, which means that it does not project below the horizontal level when it is set on a flat table.
- The projection sizes are 10 inch at 0.37 m and 60 inch at 2.22 m.
- The resolution is 854 $\times$ 480 and the screen aspect ratio is 16 : 9.

5. Select and Set Items of the Projection System

5.1. On the Distance between the Screen and Projectors

The projected screen size of our projectors is proportional to the distance between the screen and the projectors. Let d(cm), w(cm), and h(cm) be the distance between the screen and the projectors and the width and the height of the projected screen, respectively. We have $w : h = 16 : 9$ and $\sqrt{w^2+h^2} = 10 * 2.54 * d/37$. Hence we obtain $w = 0.598d$ and $h = 0.337d$.

When we set $d = 250$, we have $w = 149, h = 84$. The real width of the projected size is approximately equal to the height because the images are projected in portrait mode.

We set the distance between the projectors to 16 cm(see Fig. 2, in which only the right projector is on).

We can see that the area around the lens of the projector is bright by the reflection light from the retroreflective screen.

5.2. Selection of Items to Connect the Projectors

The advantage here is that it is easy to adjust the sizes and the positions of the left and right images when the projected images are enlarged.

Since we decided to set the projectors up vertically, we rotate the images by 90° and set the screen orientations of an iPad and an iPad mini to portrait. These images are displayed on the Safari Web browser.

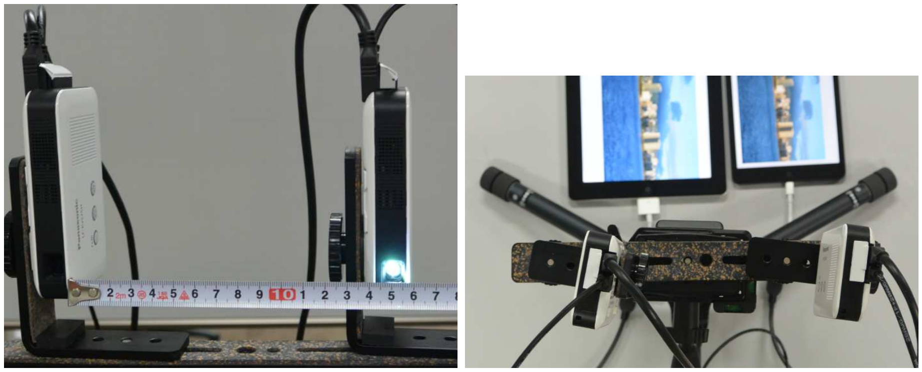

Fig. 2. Front and top view of theprojection system.

The original sizes of the images displayed above were just 460×307, so we enlarged them by more than two times and moved them slightly to adjust the displayed positions. The projectors were set up as follows:

- A free twin plate is placed on a tripod.
- Two L character type brackets are carried on the plate. Each projector is placed on a bracket. This makes it easy to adjust the distance between the projectors.
- The projectors are set to align to slightly different direction, because the images are projected to nearly the same place.

6. Conclusion

We have proposed a new stereoscopic projection system that uses a retroreflective sheet as the screen. This system is a stereoscopic projection system in which the observer does not have to wear glasses. We have determined the arrangement of the projection system and discussed where to place the projectors so that observers can perceive the images as stereoscopic. Our experiments revealed that almost all people can perceive the images projected by this system as stereoscopic.

At present, the area to perceive stereoscopic images is not large. However, we feel that the performance can be improved considerably if we use another retroreflective sheet, which should be designed for the system from the beginning, to the screen.

References

Dodgson, N. A. (2004), Variation and extrema of human interpupillary distance, *in* 'Proc. SPIE', Vol. 5291, pp. 36–46.

Japanese Standards Association (2012), *JIS Z 9117:2011 Retroreflective materials*, JSAA/JSA, Tokyo.

Panasonic Co.,Ltd (2013), 'Mini Viewer LF-PJ525H', http://dl-ctlg.panasonic.jp/manual/lf/lf-pj525.pdf.

Takanori Okoshi (2011), *Three-Dimensional Imaging Techniques*, Atara Press, Los Angels.

Yoshida, et al. (2010), RePro3D: Full-Parallax 3D Display Using Retro- Reflective Projection Technology, *in* 'ACM SIGGRAPH 2010 Emerging Technologies'.

Website:
Web-1:http://www.reflite.co.jp/english/9300_High_reflective_intensity.html, consulted 07 June 2014