International Conference on Artificial Reality and Telexistence
Eurographics Symposium on Virtual Environments (2014)
T. Nojima, D. Reiners, and O. Staadt (Editors)

Study on Visual Display for Stereoscopic Vision Based on Binocular Parallax Using Retro-reflective Projection Technology

Ryo YAMAMOTO[1], Yuji UEMA[2], Maki SUGIMOTO[1] and Masahiko INAMI[2]

[1]Graduate School of Science and Technology, Keio University, Yokohama, Japan
[2]Graduate School of Media Design, Keio University, Yokohama, Japan

Abstract

This paper discuss an image presenting method that projects information on an inner wall of a car in order to raise safety by using RPT(Retro-reflective Projection Technology). In previous research, we can see through the rear seat which is covered with retro-reflective material as a screen and recognize directly backward of a car. In this paper, we propose a projection optical system for binocular vision by using the stepwise lens array and field lens. We conducted an experiment to verify the visibility of the proposed system.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Three-Dimensional Graphics and Realism]: Virtual reality—

1. Introduction

Recently several studies have reported that image presenting methods for improving usability and safety of a car by presenting blind area information from driver's view point. Specifically, there is a wide blind area in the rear of a car.
Therefore collision accidents are happen frequently when go backward. Many drivers use a back guide monitor mounted on the front of a car. However, it is difficult to see the monitor and backwards alternately and to operate intuitively for drivers who is unfamiliar with.
In previous research, by using RPT(Retro-reflective Projection Technology) [1], it is possible to see through the rear seat covered by retro-reflective material as a screen and recognize directly backward of a car. RPT is a type of active camouflage. A projector projects the background image that processed by perspective projection matrix. The projected image is reflected by the half-mirror on a right angle and then retro-reflected by the retro-reflective screen. In previous research of a projection optical system mounted in a car by using RPT, the projector which projects background image is located on a front seat armrest and pointed to a ceiling. A driver see a rear seat through the half-mirror mounted on the side of headrest. The relationship between the observing point and projector's lens is "conjugate". It means that the length from half-mirror to the observing point is equal to the length from half-mirrror to the projector lens.
In addition, there are some application by using RPT. Koizumi et al [2] proposed Invisible Cloak. It looks as if background image can be seen through the body of a man who wear a retro-reflective coat. Ando et al [3] have developed a system that makes an observer see through an A-pillar which is located on both ends of windscreen. Fig.2 show the application by using RPT. In a projection optical system mounted in a car using RPT, a projected image is retro-reflected to the observing point. Accordingly, it is sufficient for a driver to recognize a projected image even if the small projector. Furthermore,it is possible to reduce a blooming of projected image by making the projector's iris as small as possible and making the depth of focus big.
We proposed a robust projection optical system for see-through rear seat with passenger and for a light inside of a car. However, there are some difficulty in this proposed system. The first difficulty is that this proposed system has only a monocular observing point. The second is that it is very difficult for users to turn their head. The third is lack of a depth perception. These problems make users feel stressful. In this paper, We launch step-wise lens array into this proposed optical system so as to settle these issues.

DOI: 10.2312/ve.20141372

2. Theory and method

2.1. Problems of earlier proposed method

As was mentioned in the previous section,there are some issues for the earlier system by using RPT.

- This system has only a monocular observing point.
- It is difficult for users to turn their head.
- This system has a little depth perception.

The cause of the first problem is because the lens of a projector is one. In this projector optical system, the image projected from the lens of a projector corresponds to the objecting point. Therefore, the observer has to see with one eye. The second one is simply because the observer has to turn his face 180 degrees to see from the observing point. The cause of the third one is same as that of the first one. The depth perception is provided from various parallax. Particularly, in this case, because influence of the binocular parallax is big, it is thought that depth perception is not provided when observer sees the projected image with one eye.

2.2. Proposed method

Our goal is to settle these problems of previous research. In this paper, we propose the system by using Stepwise Lens Array and Field lens. Fig.1 shows the proposed projection optical system. There are two video cameras for both eyes. Lens group including stepwise lens array and field lens divides a projected image into the image to watch with left eye and with right eye. An observer can get depth perception by the binocular parallax because each projected image is subtly different. In addition, in previous research, even though the length from half-mirror to each retro-reflective material are different, if observer sees precisely from the observing point, the gap of the projected image does not occur. An observer can see from observing points with both eyes by using stepwise lens array. The inclination of observing points are able to be changed for observer's usability by setting parameters.

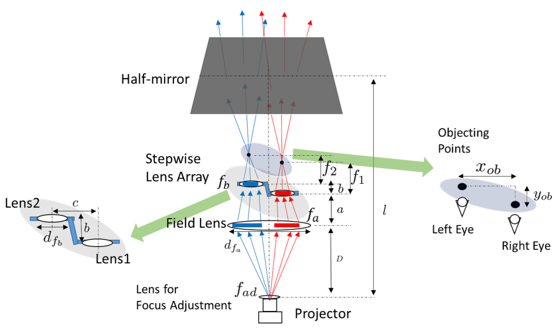

Figure 1: *Proposed projection optical system by using Stepwise lens array and Field lens*

3. Experiment Result

We implemented a laboratory experiment to confirm the usefulness of the proposed system. We performed confirmation about the difference in divided projection images seen each objecting point. We projected still images which were taken from the viewpoint of eyes and taken from a optically wrong position. The result is shown in Fig.2. The proposed method showed that the observer could recognize the projected images from the different viewpoint positions. However, we found it difficult to see from optically wrong viewpoint as Fig.2(c). Furthermore, we could confirm the aberration due to stepwise lens array and field lens.

(a) (b) (c)

Figure 2: *The projected images: (a) is for left eye, (b) is for right eye and (c) is observed from optically wrong position.*

4. Conclusion

This paper proposed a visual display for stereoscopic vision based on binocular parallax using Retro-reflective Projection Technology. We conducted an experiment to test our proposed method. In the experiment, we could recognize the projected images from the different viewpoint positions. However, the result images are blurry and have a lot of aberrations. For future extension, we will implement by using projected images considering binocular parallax in a car.

5. References

(1) N. Kawakami, M. INAMI, Y. Yanagida, T. Maeda and S. Tachi, Study for the Reality Fusion(II) -The Design and Implementation of optical camouflage-, Journal of The Virtual Reality Society of Japan, volume 3 :285-286, 1998.

(2) N. Koizumi, T. Koiwa, M. Sugimoto and M. Inami, Optical Camouflage 2.0 -The design method of transparent coat with self-image-, Journal of The Virtual Reality Society of Japan, volume 16, No. 2 :149-152, 2011.

(3) Y. Ando, R. Saito and Y. Yanagida, Study on the Screen for Projection-Type See-through Pillar, IEICE Technical Report MVE2008-1(2008-06) :1-6, 2008.

(4) Y. Ando, R. Saito and Y. Yanagida, Image Generation and Correction for Projection-based See-through Pillar, IEICE Technical Report MVE2008-106(2009-01) :51-55, 2009.

(5) T. Yoshida, K. Jo, K.Minamizawa, H. Nii, N. Kawakami and S. Tachi, A Display System for Vehicle Blind Spot Information Using Head Tracked Retro-reflective Projection Technology, Journal of The Institute of Image Information and Television Engineers (ITE), Volume 63, No. 6 :1-9, 2009.