

Changing Size of Aerial Image Formed with AIRR by Use of Clear Spheres

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1. Introduction

Aerial imaging by retro-reflection (AIRR) is an aerial-image-forming technique by use of a retro-reflector [1]. Our previous study proposed a novel steganography that utilizes AIRR and two clear spheres in the same size. The proposed technique used one of the clear spheres as a key to form an aerial image that was formed with AIRR [2].

In this paper, we change the size of the aerial image by making the size of clear spheres asymmetric. Although the aerial image formed with AIRR is displayed in the same size as the light source, the size of the aerial image can be changed using the proposed method.

2. Principle of AIRR with two clear spheres

Fig. 1 shows the principle of AIRR. This setup consists of a light source, a beam splitter, and a retro-reflector. Rays from the light source are reflected by the beam splitter. The reflected rays are retro-reflected, that is, reflected reversely at the incident positions on the retro-reflector. The retro-reflected rays are converged to the position of the plane-symmetrical of the light source with respect to the beam splitter. Fig 2 shows the diagram of the two same spheres are placed plane-symmetrically regarding the beam splitter. Rays from the light source are refracted by the clear sphere 1. Then, retro-reflected rays are refracted again by the clear sphere 2. Consequently, an aerial image is formed.

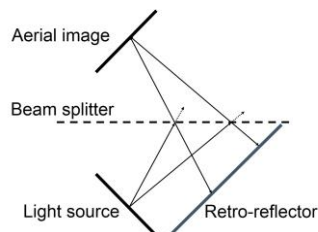


Fig. 1 Principle of AIRR.

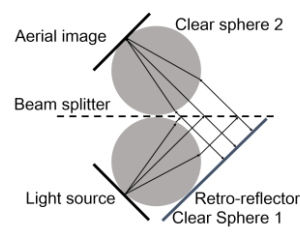
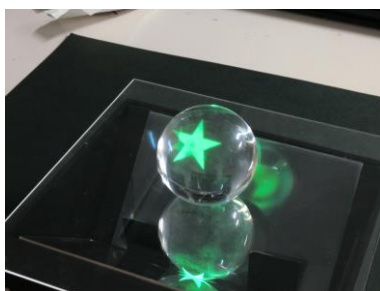


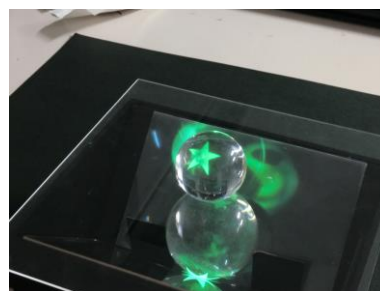
Fig. 2 Principle of AIRR with two clear sphere.

3. Experimental Results

Fig. 3 shows the observation results of an aerial image when the size of the clear sphere 2 is (a) the same, (b) smaller, and (c) larger than the size of the clear sphere 1. By changing the size of the clear sphere 2, we have succeeded in changing the size of the aerial image. When the clear sphere 2 was changed smaller, the aerial image became smaller, however the aerial image due to the surface reflection of the clear sphere 1 was overlapped. When the clear sphere 2 was changed larger, the aerial image became larger, however it was found that the visible range is affected by the size of the clear sphere 1.



(a) 50mm diameter acrylic sphere (same size of the under sphere).



(b) 30mm diameter acrylic sphere (smaller than the under sphere).



(c) 90mm diameter acrylic sphere (larger than the under sphere.).

Fig. 3 Change of aerial image when changing size of clear sphere on beam splitter.

3. Conclusions

We have succeeded in changing the size of the aerial image using clear spheres of different sizes.

References

- [1] H. Yamamoto, Y. Tomiyama, and S. Suyama, Optics Express, Vol. 22, Issue 22, pp. 26919-26924 (2014).
- [2] K. Fujii, S. Ito, S. Maekawa, and H. Yamamoto, Proc. IP'17, 21PM-1-3 (2017).