Aerial-Imaging Steganography by Use of a Transparent Object as the Key

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1. Introduction

Aerial imaging by retro-reflection (AIRR) [1] is one of the aerial imaging techniques. AIRR forms a floating real image in the mid-air. The configuration of conventional AIRR requires a light source, a beam splitter, and a retro-reflector. Our previous study proposed a novel steganography that utilizes AIRR and two transparent spheres in the same size. The proposed method used one of the transparent spheres as a key to form an aerial image that was formed with AIRR [2, 3]. Although use of spheres reduces the required size of the retro-reflector, out-coming rays from the beam splitter are not well-scrambled. Then, the apparent image without the decoding sphere is a skewed image. To make the apparent image more scrambled, we aim to use a transparent 3D object as a key to decode the steganography.

In this paper, two plastic bottles with wavy surface are filled with water and are arranged in plane symmetrical with respect to a beam splitter to form an aerial image. The second bottle is used for the key to decode the scrambled aerial image.

2. Principle of Aerial Imaging by Retro-Reflection by Use of Two Transparent Spheres

Fig. 1 shows the principle of our proposed method where the two same transparent spheres are placed plane-symmetrically regarding the beam splitter. The light emitted from the light source passes through the transparent sphere 1 with refraction, and then the light is reflected by the beam splitter and enters to the retro-reflector. The retro-reflected light passes through the beam splitter and is refracted by the transparent sphere 2, which forms aerial image at the plane-symmetrical position of the light source with respect to the beam splitter. Fig. 2 shows the observation results of aerial images using two transparent spheres.

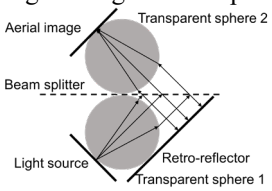

Fig. 1 Principle of imaging an aerial image with two clear spheres.

Fig. 2 Principle of imaging an aerial image with two clear spheres.

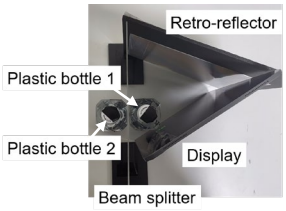

Fig. 3 Experimental setup.

3. Experimental Results

Fig 3 shows the experimental setup. Two plastic bottles arranged plane-symmetrical position with respect to the beam splitter. Fig. 4 (a) shows the observation result of aerial image without plastic bottles. Fig. 4 (b) shows the observation result with two plastic bottles. As in Fig. 4 (a), the aerial image of "20" was formed. Fig. 4 (c) shows the observation result without the decoding bottle. The aerial image was scrambled because it is not a plane symmetric optical arrangement. These results shown that it is possible to form an aerial image using a plane symmetric optics using a shape other than a sphere.

(a) (b) (c)

Fig. 4 Observation results of Aerial images (a) without plastic bottles, (b) with two plastic bottles, (c) with only plastic bottle 1.

4. Conclusion

We have confirmed that we can perform aerial imaging steganography keyed to transparent objects other than spheres using a plastic bottle filled with water.

References

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