Forming Two-View Aerial Signage Over an LED Panel by Use of a Retro-Reflective Slit-Array

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ABSTRACT

We propose an optical system for two-view aerial signage over an LED panel. A retro-reflective slit array and a beam splitter are placed in front of the LED panel and form the aerial image over the LED panel. The aerial signage shows different apparent images depending on the viewing directions.

1 INTRODUCTION

Aerial imaging by retro-reflection (AIRR) has been proposed as a method to form an aerial image for a wide range of viewing angle [1]. Prospective applications of aerial displays include aerial large-scale signage for traffics, advertisement, and amusements. In the conventional method, there is one-to-one relationship between an aerial image and a light-source display. Recently, it has been demonstrated that two different aerial images can be generated at different locations from one light source by using slit array and two beam splitters in AIRR [2]. However, the previous design requires a large foot space to install the aerial signage system.

The objectives of this paper are to propose a novel optical design for two-view aerial signage and to confirm our design with a prototype aerial signage by use of an LED panel. Our proposed optical system can show two different images depending on the viewing directions while using single LED panel and requires just several times of the LED foot space.

2 PRINCIPLE

2.1 Aerial imaging by retro-reflection

The principle of AIRR is shown in Fig. 1. AIRR is composed of three elements: a light source, a retro-reflector, and a beam splitter. Light from the light source goes to the beam splitter and splits in reflected light and transmitted light. The reflected light impinges the retro-reflector and go back to the beam splitter after the retro-reflection. The light splits again on the beam splitter. The transmitted light converges to the position of plane symmetry of the light source regarding the beam splitter.

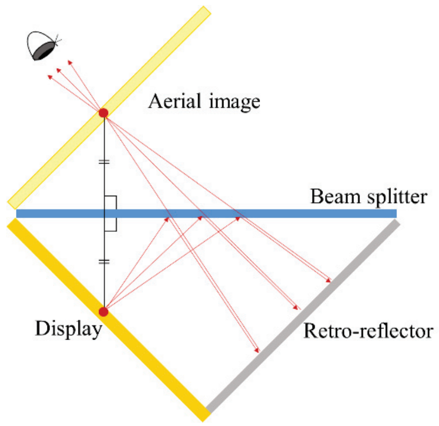

Fig. 1 The principle of AIRR.

2.2 Autostereoscopic LED display by use of a parallax barrier

Our optical design is inspired by a stereoscopic display by use of a parallax barrier [3], which is shown in Fig. 2. Interleaved images are shown on an LED panel and a slit array, called parallax barrier, is placed in front of the LED panel. Different LED pixels are visible through the apertures of the slit array depending on the viewpoint. The left and right viewing positions depend on the slit pitch and the distance between the slit array and the LED panel.

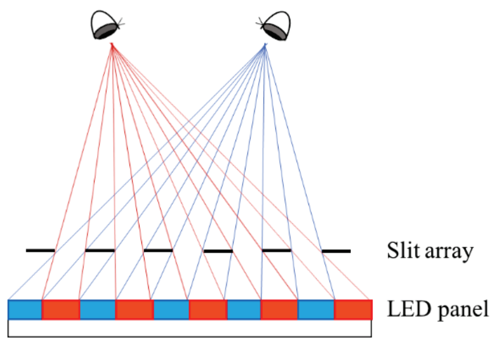

Fig. 2 Autostereoscopic LED display by use of parallax barrier.

2.3 Forming Two-View Aerial Signage Over an LED panel by Use of a Retro-Reflective Slit-Array

Fundamental structure to form two-view aerial signage in front of an LED panel is shown in Fig. 3. The parallax barrier in Fig. 2 is replaced by a retro-reflective slit array, which is a punctuated retro-reflector. The retro-reflective slit array generates two-view directivity. The retro-reflective slit array and the beam splitter converge light at the plane-symmetrical position of the LED panel regarding the beam splitter.

Moreover, to increase the visibility of aerial images, we made the LED invisible from the front by inserting a polarizer and a reflective polarizer in a cross Nicol arrangement, as shown in Fig. 4. In this case, the light from the display penetrates polarizer and reflects at the reflective polarizer. The polarization angle of the retro-reflected light is rotated by 90 degrees after penetrating the quarter-wave retarder twice. Therefore, the retroreflected light transmits through the reflective polarizer and converges into the plane symmetric position of the light source regarding the reflective polarizer.

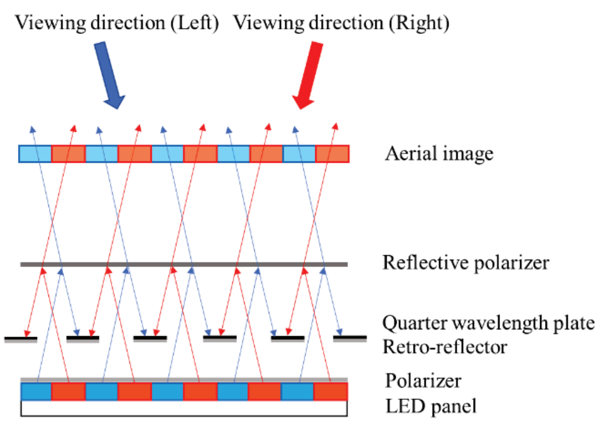

Fig. 3 Fundamental setups to from two-view aerial signage by use of a retro-reflective slit array.

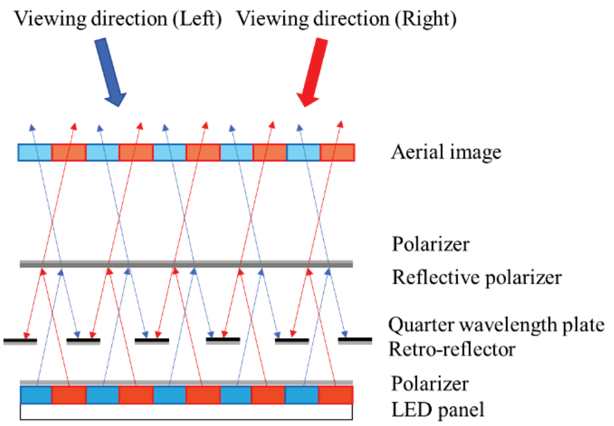

Fig. 4 Improvement of visibility by use of a polarizer to block the direct view on the LED panel.

3 EXPERIMENTS

We have developed a preliminary prototype for experimental confirmation of our optical design. A 6-mm-pitch 32 × 32 LED panel is used for the light source. The retro-reflective slit array, shown in Fig. 5, is fabricated to have a pitch twice as the pitch of the source LED panel. The displayed image on the LED panel is composed of two images that are divided into horizontal rows in every two rows and alternately interleaved in an image. The interleaved displayed image used for experiments is shown Fig. 6. In this configuration, the viewing distance of the separated image is sufficiently large (theoretically infinity) compared to the distance of the retro-reflective slit array from the LED panel.

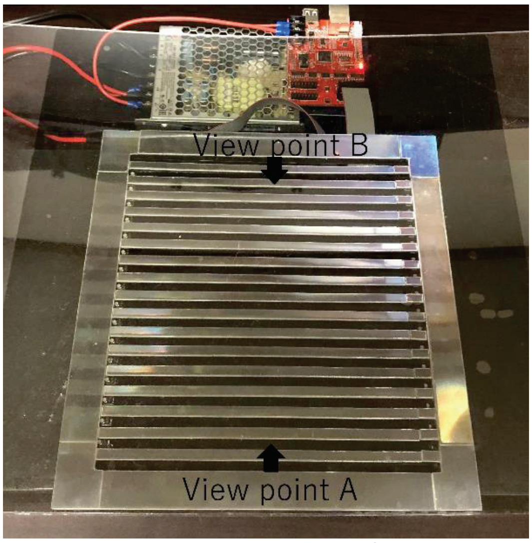

Fig. 5 Experimental setups to confirm our optical design for two-view aerial signage.

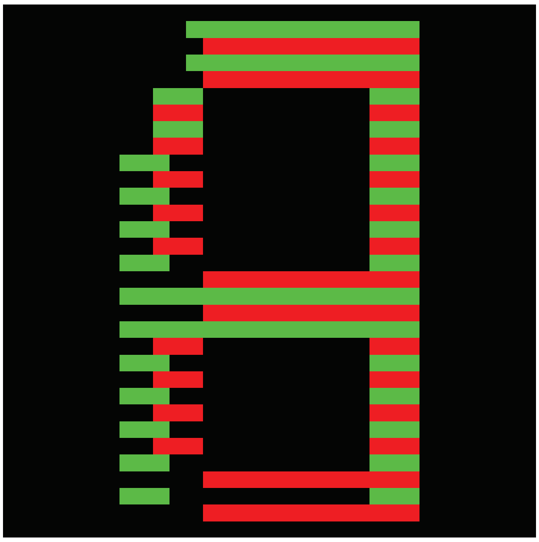

Fig. 6 An interleaved image shown on the light-source LED panel.

We have confirmed separation of the displayed interleaved image. Viewed images of the LED panel through the slit array are shown in Fig. 7 and Fig. 8. Our slit array separated the interleaved images into two images.

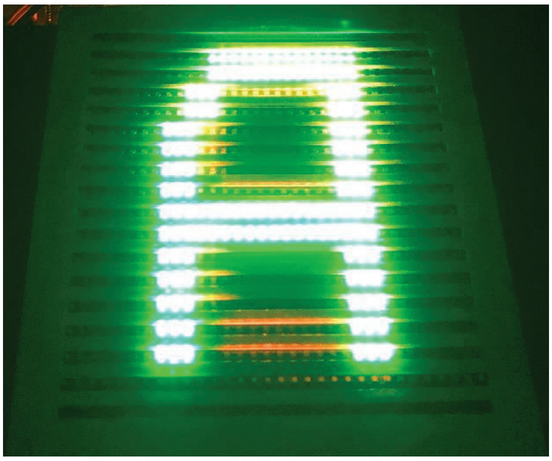

Fig. 7 Viewed image from an upward direction of the LED panel.

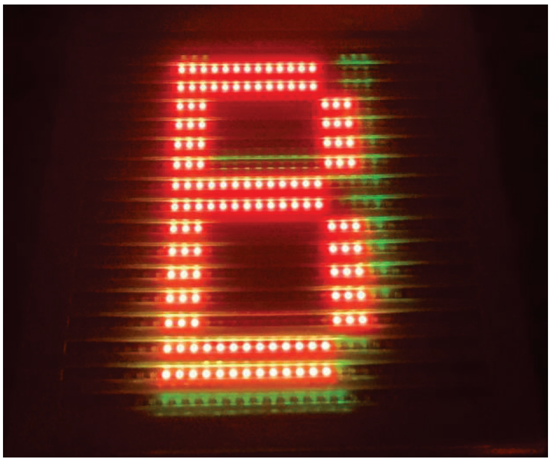

Fig. 8 Viewed image from an upward direction of the LED panel.

The observation results of focusing the aerial image with a moving screen are shown in Fig. 9. The aerial image is clearly formed at the aerial image position, which is the plane-symmetrical position of the light-source display regarding the beam splitter. The observed image on the screen is blurred when the screen is out of the focusing distance. Note that the screen observation does not maintain the directivity of the two-view aerial signage.

Direct observation results of the aerial images formed with the fundamental setups (Fig. 3) are shown in Fig. 10 and Fig. 11. From the viewpoint A, a green letter ‘A’ is visible in front of a red letter ‘B’, which is shown on the LED panel. From the viewpoint B, a red letter ‘B’ is visible over a green letter ‘A’.

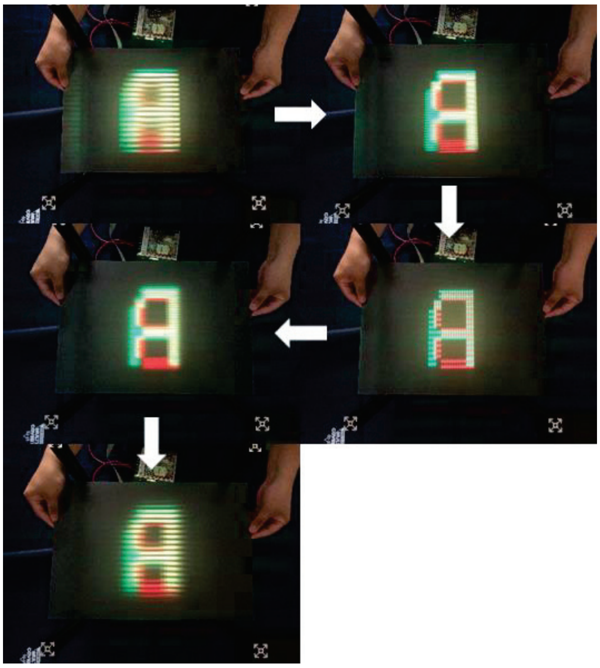

Fig. 9 Screen observation results of the formed aerial signage.

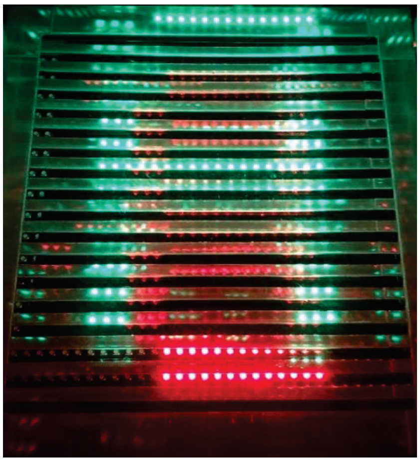

Fig. 10 Viewed aerial image from the viewpoint A.

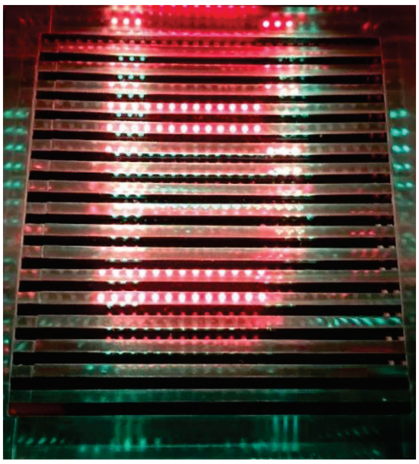

Fig. 11 Viewed aerial image from the viewpoint B.

Aerial images formed with the improved setups (Fig. 4) by use of polarization are shown in Fig. 12 and Fig. 13. From the viewpoint A, a green ‘A’ was visible on the aerial signage. From the viewpoint B, a red ‘B’ was visible on the same aerial signage. Although the luminance of the aerial image with the improved setup (Fig. 4) is lower than the fundamental setups, we have confirmed that the reflective polarizer blocks the direct light from the light LED panel.

4 CONCLUSION

We have proposed an optical system for two-view aerial signage over an LED panel. Since the formed aerial screen in front of an LED panel shows different information depending on the viewing direction, two opposing people can see different aerial images from a single aerial display system. Showing aerial signage right in front of an LED panel reduces the foot space, which is suitable for a large-scale installation.

REFERENCES

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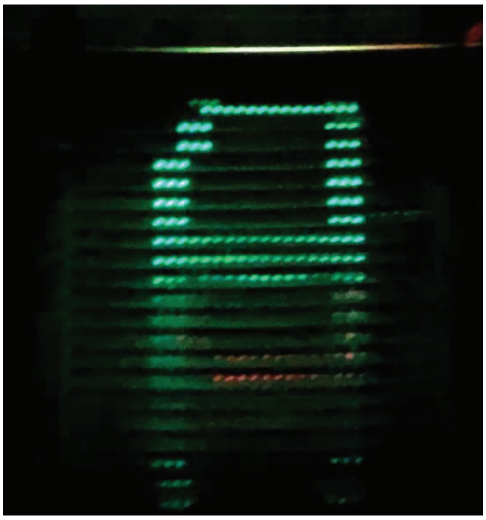

Fig. 12 Viewed aerial image from viewpoint A.

Fig. 13 Viewed aerial image from viewpoint B.