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Hand-waving decodable steganography by use of 960Hz LED panel

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1. Introduction

Digital signage become pervasive everywhere. Each signage required of drawing more attentions. We developed 480Hz LED display [1] and utilized the LED display to provide a kind of enjoyment in decoding a steganography. The proposed steganography is hand-waving decodable [2]. However, there was an unintentional decoding problem, that is, observers perceived the embedded information without hand waving. They perceive the silhouette when viewing the LED screen with fast head movements. This problem may be solved by increasing the switching rate of the LED panel.

In this paper, we investigate hand-waving decoding by use of 960Hz LED panel. We report the experimental results for hand-waving decoding and head-motion decoding.

2. Realization of Hand-Waving decodable Display

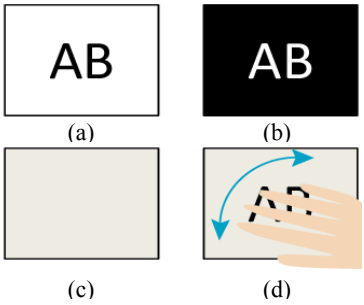

Fig. 1. Principle of hand-waving steganography. A pair of images shown in (a) and (b) are alternatively displayed at a high frame rate. (c) A viewed image looks plain. (d) Viewing through a waving hand decodes the embedded information.

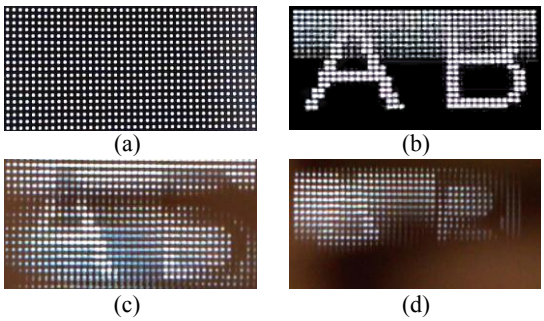

Fig. 2. Observations of 960-Hz image where "AB" is embedded. (a) A frame in a 60Hz video clip looks white. (b) A frame in 1200Hz video clip shows the embedded information. (c), (d) Typical decoded results in a 60 Hz video clip that was taken through a waving hand in front of the video camera.

The principle of hand-waving decodable steganography is illustrated in Fig. 1. A pair of encoded images, as shown in Fig. 1 (a) and (b), are shown on a high-frame-rate LED display. Because the images are switched at a high frame rate (above 240Hz), an observer perceives the LED screen as a uniform image, as illustrated in Fig. 1 (c). When the LED screen is viewed through a waving hand, however, intercepted region shows parts of the embedded information, as illustrated in Fig. 1 (d). The observer can perceive the whole information by viewing through the waving hand continually.

Experimental results are shown in Fig. 2. Direct viewing does not decode the embedded information, as shown in Fig. 2 (a). The video clip was taken with a 60Hz video camera. The whole screen looks white because the pair of embedded image were switched at 960Hz and averaged image were detected by the 60Hz video camera. A 1200Hz video camera separates the pair of images, as shown in Fig. 2 (b).

Fig. 2 (c) and (d) show decoded results with a hand waving. These video clips were taken with a 60Hz video camera while waving a hand in front of the camera lens. A part of the embedded information was decoded in a single clip. When we decode the embedded image, we perceive flickered contrast changes between the embedded letter and the background.

3. Decoding by head movement

Decoding results with a horizontally moving camera are shown in Fig. 3. Fig. 3 (a) and (b) show LED screens showing the embedded image pair switched at 480Hz and 960Hz, respectively. Embedded letters "AB" at 480Hz were visible, while no significant letters were observed on the 960Hz-switched screen. The results suggest that the 960Hz LED display may solve the unintentional decoding problem.

4. Conclusion

We have realized hand-waving decodable steganography display by use of a 960 Hz LED display. It was confirmed that embedded image pairs switched at 960Hz is decodable by hand waving. Furthermore, the experimental results suggest 960Hz switching will prevent decoding with head motion without hand waving.

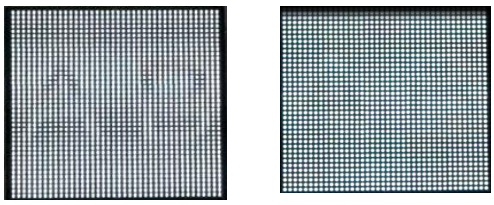

Fig. 3. Observations with a moving camera. Hand-waving decodable displays with (a) 480Hz and (b) 960Hz refresh rates were captured by a 60Hz video camera with moving horizontally.

References

[1] H. Yamamoto, M. Tsutsumi, R. Yamamoto, S. Suyama, Proc. SPIE **7956** (2011) 7960R.
[2] S. Farhan, S. Suyama, H. Yamamoto, Proc. The 1st Laser Display Conference (LDC'12), LDCp7-22 (2012).