Visual Communication with Successive Reading of Public and Secret Information by Generating Dual-Layer Images
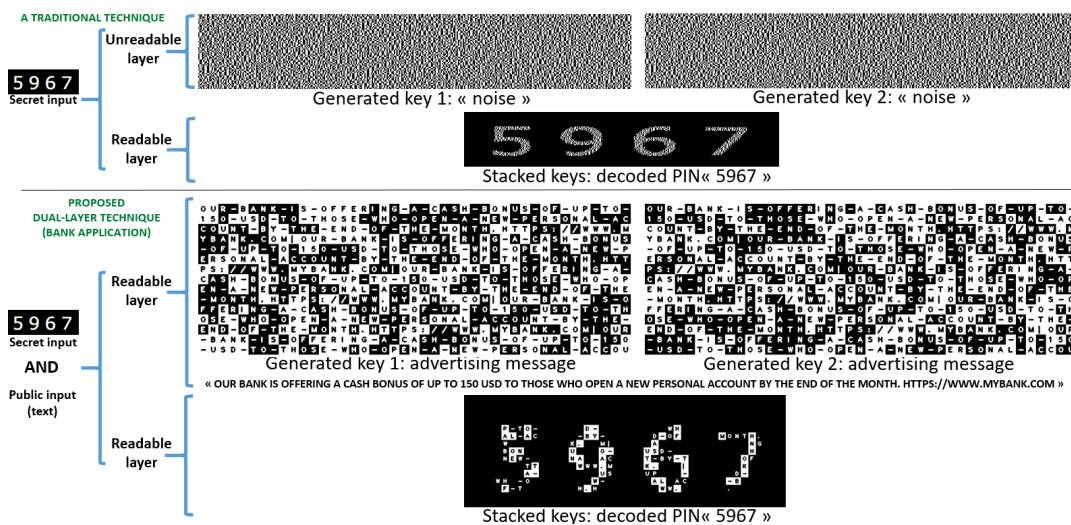
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Figure 1: *(Top) a traditional visual cryptography result. (Bottom) Obtained Dual-Layer result for a visual-based bank application. For this latter, an advertising message and a secret code are successively read from key images without using a computer.*

Abstract

In visual communication, visual cryptography is a technique that permits to share secret information through a two-step process. In a common processing scheme, two key images (ciphered images) are generated from a binary secret image. Then, the generated key images are sent to a recipient via two different communication channels. Once key images collected, the secret information is decoded via the human vision system by observing the superposition of the two key images. In this context, each key image generally has its appearance as a mix of black and white pixels. In this paper, we present a technique that permits to personalize the appearance of generated key images by making them exploitable for displaying visible information (e.g.; textual information) while simultaneously embedding secret information. A family of dual-layer images is thus highlighted towards fostering the development of visual creations. Experimental results show visual applications with successive reading of public and secret information from generated Dual-Layer key images.

1. Introduction to visual cryptography

Visual cryptography is an active research area for visual secret sharing (e.g., [SMMK19]). In a traditional scheme that is shown in top part of Fig. 1, two key images are generated from a binary image of a PIN by using a random encoding process; e.g. pixel expansion process shown in Table 1(a). This makes the appearance of the generated key images completely textured with a mix of black and white pixels as a dense salt-and-pepper noise. Then, the generated

key images are communicated to the recipient by using two different communication channels for security reasons. Once the generated key images are collected, they are stacked for revealing the secret information. The key images are generated in order to directly be readable through the human perception once stacked. Hence, these keys can be printed on transparent sheets, then stacked for visual decoding without computer-based calculations (see stacked keys in top part of Fig. 1).

Table 1: *Pixel expansion with traditional and proposed rules.*

Figure 2: *DL key images for 2-player quiz application. One same question is textured on two cards. After giving the potential responses orally, overlapped cards reveal the solution (resized in (b)).*

Figure 3: *Inputs and successive reading; text layer and shape layer.*

2. Motivation

In this paper, targeted applications are focused on developments of visual creations. Visual effects and direct readability through human perception are searched. Besides, traditional key images look noised. De facto, their surfaces are completely unexploited for displaying information (see generated keys in top part of Fig. 1).

Personalizing key images – Surfaces of key images can be exploited for displaying information (e.g., sender information, text). Bottom part of Fig. 1 illustrates a bank application where key images are generated from two inputs (a secret PIN and an advertising message). Both key images and stacked key images (reduced sizes) are readable thanks to generated Dual-Layer key images (DL key images). By this way, visual creations can be expected in varied contexts such as business promotions, visual entertainments, visual effects. In practice, key images can be printed on A6-format transparent sheets for a visually pleasant reading.

Related work – Computer graphics research emerges in QR codes for embedding hidden information while making their appearances aesthetic and stylized [XSL*19]. In this paper, a similar double effect is searched by using the surface of key images as a medium of visual communication for the successive reading of public and secret information. In a previous work [HM18], we presented a technique inserting pictograms on key images. Hereafter, the generation of DL key images is exploited for inserting richer contents.

3. Generating Dual-Layer key images

Pixel expansion rules are usually applied for generating two key images from a binary image (Table 1(a)). The input is analyzed pixel-by-pixel. According to each value (white or black), two two-pixel masks ("noise") progressively generate two key images by a respective mask mapping. Presently, the technique works in such a way that the surface of key images can be mapped with an important quantity and diversity of readable information (e.g.; a text) while still embedding a secret information (e.g.; a code) for the hidden layer. Indeed, a textual message can be additionally given as input. For each character (e.g.; from an alphabet) positive and negative masks are generated (Table 1(b)). Then, a hash map is built between the input text and the mask of characters. Finally, for each pixel parsed, a character of the text that is located at the same location provides the appropriate mask of letter. This means that the pixel expansion is done by replacing each pixel by a small image of a letter with respect to a given text. If the given text is short, the keys are fulfilled by duplicating the text.
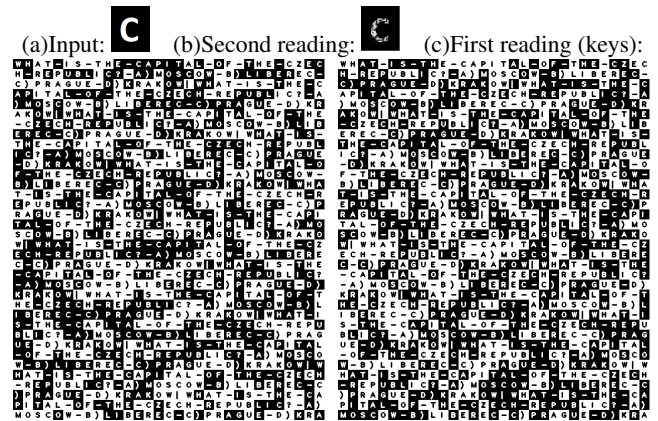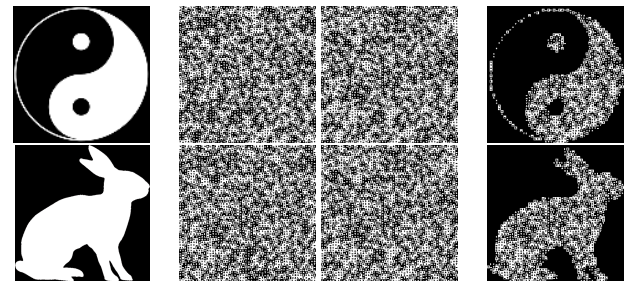
4. Applications and discussion

An alphabet-based visual cryptography technique is proposed for creating double visual communication effects. A random process for noise generation is coupled with an arrangement of letters for displaying content on key surfaces. Generated DL key images permit successive reading of public and secret content without using a computer. A bank promoting application (Fig. 1) and a card game (Fig. 2) illustrate the principle. Secret layer can be digits, letters or even shapes (Fig. 3). Generated writing and shapes have unsual aspects. DL card games could be tested for shape identification by patients in neuro-visual rehabilitation. ASCII art [XZX*17] could be exploited for displaying shapes on public layer.

References

[HM18]   HAMMOUDI K., MELKEMI M.: Personalized shares in visual cryptography. *Journal of Imaging 4*, 11 (2018). doi:10.3390/jimaging4110126. 2

[SMMK19]   SELVA MARY G., MANOJ KUMAR S.: Secure grayscale image communication using significant visual cryptography scheme in real time applications. *Multimedia Tools and Applications* (Jan 2019). doi:10.1007/s11042-019-7202-7. 1

[XSL*19]   XU M., SU H., LI Y., LI X., LIAO J., NIU J., LV P., ZHOU B.: Stylized aesthetic QR code. *IEEE Transactions on Multimedia* (2019), 1–1. doi:10.1109/TMM.2019.2891420. 2

[XZX*17]   XU X., ZHONG L., XIE M., LIU X., QIN J., WONG T.: ASCII art synthesis from natural photographs. *IEEE Transactions on Visualization and Computer Graphics 23*, 8 (Aug 2017), 1910–1923. doi:10.1109/TVCG.2016.2569084. 2