Improving Machine Readable Codes Aesthetics: a Novel Iconographic Encoding Standard

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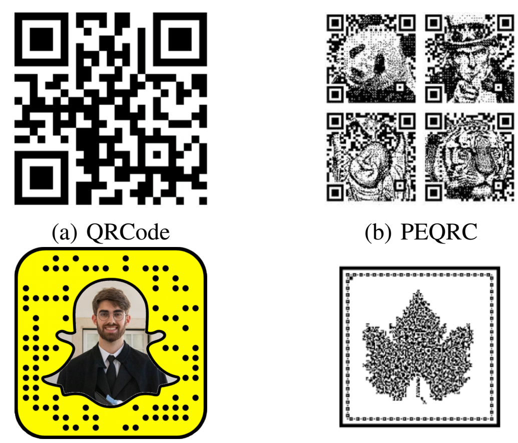
***Abstract*—This paper introduces the novel Icon- based Graphic Code (IbGC), which is a new paradigm for Machine Readable Code (MRC) with configurable aesthetics. In IbGC, data is encoded as a sequence of icons positioned over the code region. The design and position of the icons is designed for each application, allowing complete control of the final aesthetics of the MRC.**

***Index Terms*—machine readable code, aesthetic coding, deep learning, information security**

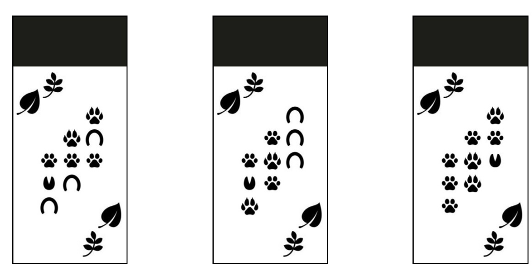
I. Introduction

The use of Machine Readable Codes (MRC) became the standard in the industry for process control. Due to this widespread usage, companies have begun to engage in innovative practices concerning the customization of their MRCs. This customization entails the creation of schematic representations [1]–[3], as depicted in Figure 1b, as well as the integration of their distinctive visual branding elements, as illustrated in Figure 1c, in contrast to the traditional QR code composed of square black or white blocks (Figure 1a). More recently, the creation of the Graphic Code [4]–[6] allowed the possibility of aesthetic control by integrating a MRC with base images, as shown in Figure 1d. However, similarly to other MRC technologies, data was still represented as a sequence of black and white cells.



(a) QRCode (b) PEQRC (c) Snapchat Code (d) Graphic Code

Fig. 1: Different types of Machine Readable Codes.



(a) (b) (c)

Fig. 2: Icon-based Graphic Code (IbGC).

To improve the appearance of MRCs, we propose the Icon-based Graphic Code (IbGC). In such novel paradigm, data is encapsulated in an iconographic format entirely configurable for each application: the information is encoded in a sequence of icons, hereinafter refereed to as *variables*, while control or positioning patterns, an equivalent of position landmarks in QR codes, are also replaced by icons, subsequently referred to as *landmarks*. Figure 2 show some examples of IbGC with 3 different messages. Note that the variable icons in the center are different on cases a), b) and c).

II. Encoding

For the creation of IbGC, a designer must specify the *landmarks*, as in Figure 3, and where they should be positioned, preferably in such disposition that spams over the entire code for a proper detection/rectification. Similarly, the designer creates the *variables* that compose our coding scheme, as shown in Figure 4, as well as the *variable* positions. The message to be encoded is translated into a sequence of *variable* icons, which are placed in the allowed positions, leading to an MRC such as the ones in Figure 2.

(a) (b) (c)

Fig. 3: Example of *landmark* icons.

(a) (b) (c) (d)

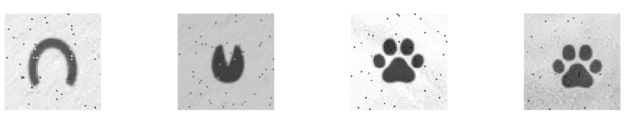
Fig. 4: Example of *variable* icons.

III. Decoding

The decoding of IbGC is performed in two steps. First, our library implements a template matching-based system for *landmark* detection within video streams. By processing the estimated *landmark* positions, we perform a crop on each *variable* position. Then, using a CNN-based classifier designed for the *variable* icons, we find the symbol contained in each position and convert back to the original message.

A. Training

To train the *variable* classifier, during the design of the icons used to encode the messages in IbGC, we create a synthetic database for each icon containing different padding, scale, rotation, blur or crop, and also introduces artificial salt and pepper noise. Finally, to simulate the printing and handling of MRCs, we implement a paper texture augmentation, where we merge the *variable* icon with a background image that resembles the texture of crumpled paper, as shown in Figure 5.



(a) (b) (c) (d)

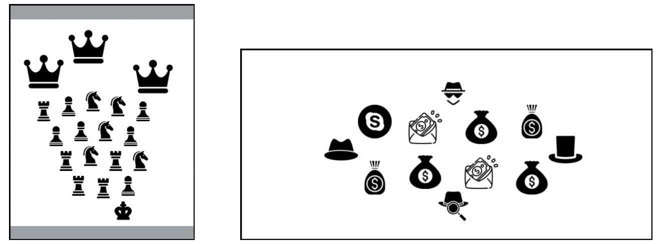
Fig. 5: Example of a synthetic dataset of *variable* icons containing a crumpled paper texture as background.

IV. Design examples

In order to highlight the capabilities of the proposed IbGC, we generate examples of MRC with entirely new design, which are contained in Figure 6. Our tests showed that the decoding accuracy depends on the quality of the camera sensor and size of the printed code. In Figure 7 the smaller versions (3, 4, 5) were not successfully detected by the template matching.

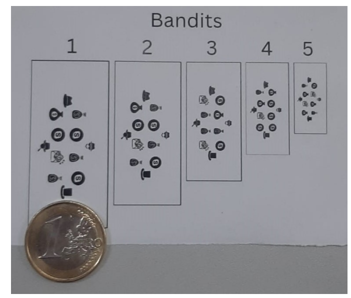
V. Conclusions

In this paper, we we introduce a concept to enhance the visual appearance and versatility of MRCs by introducing the Icon-based Graphic Code (IbGC), a novel system where data is encoded in customizable icons. This new approach enables a more flexible and aesthetically controlled way of embedding information, offering applications a greater degree of creative freedom in their MRC implementations Future versions of the library will contain an improved landmark detection and an error correction to alleviate limitations in the size of the printed code.



(a) (b)

Fig. 6: Different designs of IbGC. (a) Chess. (b) Bandit.



(a)

Fig. 7: Decoding tests using the Bandit code.

References

[1] L. Li, J. Qiu, J. Lu, and C.-C. Chang, "An aesthetic QR code solution based on error correction mechanism," *Journal of Systems and Software*, vol. 116, pp. 85–94, 2016.

[2] M. Xu, H. Su, Y. Li, X. Li, J. Liao, J. Niu, P. Lv, and B. Zhou, "Stylized aesthetic QR code," *IEEE Transactions on Multimedia*, vol. 21, no. 8, pp. 1960–1970, 2019.

[3] M. Xu, Q. Li, J. Niu, H. Su, X. Liu, W. Xu, P. Lv, B. Zhou, and Y. Yang, "ART-UP: A novel method for generating scanning-robust aesthetic QR codes," *ACM Transactions on Multimedia Computing, Communications, and Applications*, vol. 17, no. 1, 2021.

[4] L. Cruz, B. Patrão, and N. Gonçalves, "Halftone pattern: A new steganographic approach," in *Annual European Association for Computer Graphics Conference: Short Papers*, Delft, The Netherlands, April 2018, pp. 21—24.

[5] B. Patrão, L. Cruz, and N. Gonçalves, "Large scale information marker coding for augmented reality using graphic code," in *IEEE International Conference on Artificial Intelligence and Virtual Reality*, Taichung, Taiwan, Dec. 2018, pp. 132–135.

[6] L. Cruz, B. Patrão, and N. Gonçalves, "Graphic code: A new machine readable approach," in *IEEE International Conference on Artificial Intelligence and Virtual Reality*, Taichung, Taiwan, Dec. 2018, pp. 169–172.