Generation of Photorealistic QR Codes

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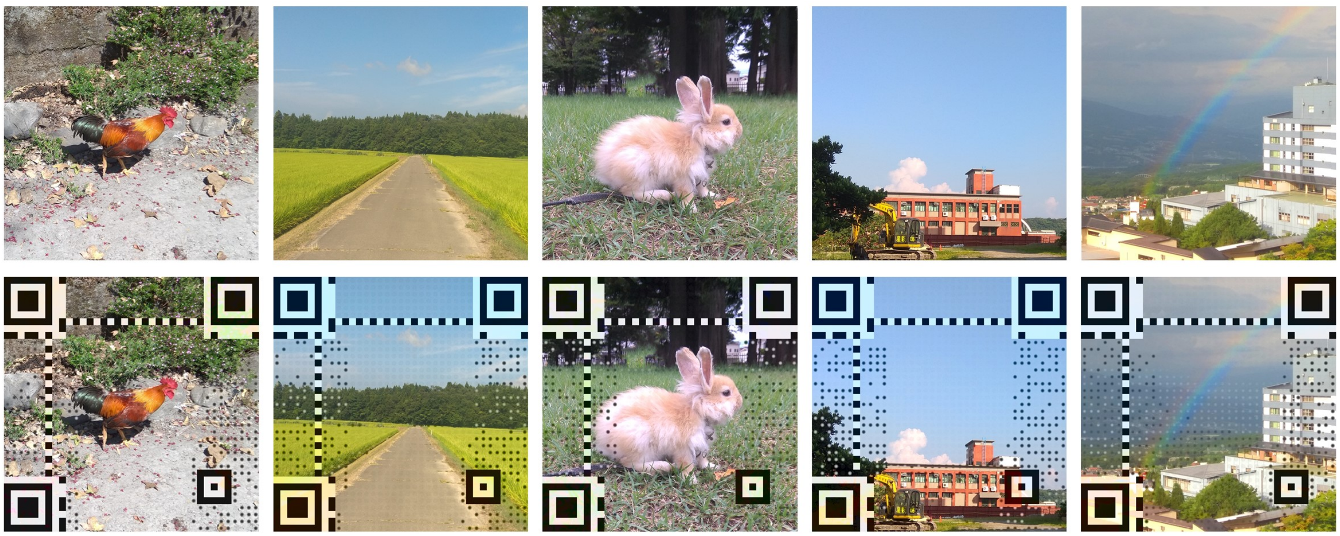

Figure 1: Top: input images. Bottom: photorealistic QR codes with their corresponding URLs.

CCS CONCEPTS

• **Computing methodologies → Image processing**.

KEYWORDS

photorealistic QR code, Gauss-Jordan elimination, Reed-Solomon code, blending optimization

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1 INTRODUCTION

A quick response (QR) code is a 2D barcode that can be printed on various products and quickly scanned by different mobile devices. However, attracting people to scan QR codes is difficult due to the lack of aesthetic elements. Therefore, some artists have tried to incorporate aesthetic elements into QR codes. Methods for embedding aesthetic images into QR codes have also been proposed [Chu et al. 2013; Lin et al. 2015, 2013; Peled 2019]. Figure 2(b-e) shows some aesthetic QR codes generated by differently recent methods. However, excessive modifications of the QR code may complicate the successful decoding of the devices. Thus, maintaining the completeness of the image and the decoding capability of the QR code simultaneously has become a major topic in research.

Lin et al. [2015] used one of the characteristics of QR code, that is, Reed–Solomon (RS) code, which does not affect the content of QR code when operating XOR (Gauss-Jordan elimination) on it. The QR code can also be successfully decoded by maintaining the correct information in an area calculated by one-third of the side length of the QR code. They adjusted the QR code to make its closeness to the binary image without affecting its content. Then, an embedded image, which is decodable through optimization and a specific blending strategy, was generated. However, the method may increase the errors of the QR code. Thus, the current study proposes improvements and attempts to reduce the error rate of the QR code to 0 on the basis of Lin et al.'s method [2015].

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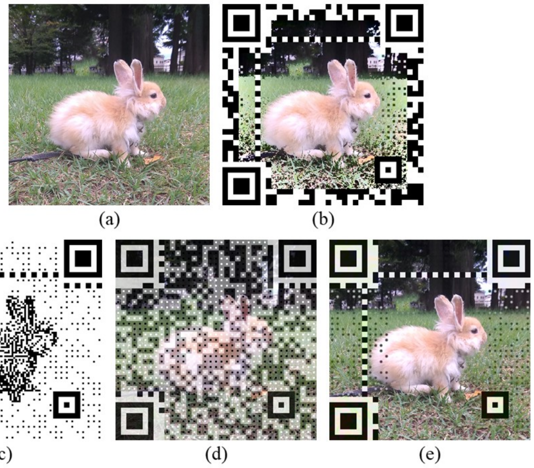

Figure 2: (a) Input image. (b-e) are the results generated by Lin et al. [2015], Chu et al. [2013], Visualead [2019], and our method, respectively.

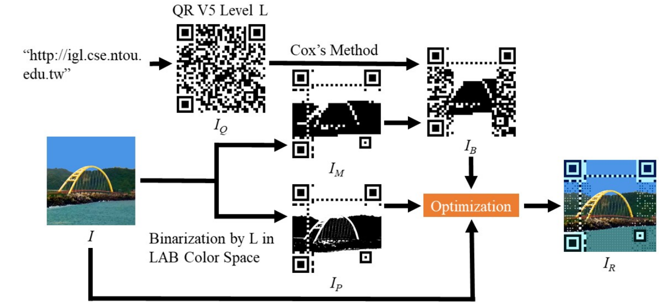

Figure 3: System procedure. In the first stage, we first binarize the input image through the L value in the LAB color space, where we have two types of binarization: binarization in module base (I_M) and that in pixel base (I_P). We generate a standard QR code (I_Q) and use Cox's method [2019] to rearrange it. Then, we generate a baseline QR code (I_B) that is close to I_M and utilize the original input image (I), pixel-based QR image (I_P), and baseline QR code (I_B) to generate the final photorealistic QR code (I_R) through optimization.

2 APPROACH

The designed method is based on Lin et al. [2015]. Chu et al. [2013] showed that the area calculated by one-third of the side length of the module size maintains the correct information, which enables the QR code to be decoded correctly. In our method, we attempt to ensure that the central region of the module in the QR code that is calculated by one-third of the side length has the same information as the QR code. We also refer to Trpovski's strategy [Trpovski 2017] and modify the central region of the module into a circular shape to ensure that the final output of the photorealistic QR code is completely free of error.

Figure 3 shows the proposed system procedure. In the first stage, we generate a binary QR code with an appearance close to that of the input's binary image and then pass it to the next stage. In the second stage, we design an objective function for optimization to guarantee that the central region of the module with the original information of the QR code has the correct information and that the appearance of the QR code is as similar as possible to that of the original input image. Some regions appear to have the correct information and look close to the original input image at the same time. If the original input image is different from the QR code information, then the abovementioned problems are mutually exclusive. Blending Optimization can be used to solve this problem for obtaining an optimal solution.

3 RESULTS AND CONCLUSION

In our experiments, each photorealistic QR code is generated using version 5 and error correction level L as input in Zebra Crossing (ZXing) decoder to calculate the error rate. 17 images used in the study [Lin et al. 2015] are adopted for comparison. After experiments, the average error rate of our photorealistic QR codes is 0% smaller than 3% provided by [Lin et al. 2015]. Figure 1 shows some photorealistic QR codes generated by the proposed method. In this study, we propose an efficient way to improve the QR code generation method by Lin et al. [2015]. First, the Cox's method [2019] is utilized to create a basic QR code that is decodable but poor in visual quality. Then, the blending mechanism used by Lin et al. [2015] is modified to improve the visual quality while avoiding the effects on the scanability/readability of the QR code. The decodable region is further extended to all positions of the adjustable area to embed the image into the QR code completely. The experimental results show that the proposed method reduces the error rate to 0% without affecting the visual effect and maintain the processing complexity to near-instant.

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