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An Optimization Based Approach for Image Embedding in QR Codes: A Review

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***Abstract*-This paper introduces the concept of image embedding in the QR (Quick Response) code. The main confront of any embedding method is the fact that they should be decodable by standard applications. The embedding of image pixels into the QR code brings the changes in the luminance of the code, deforms the binarization thresholds and thus increases the probability of detection error. In the QR code embedding process, the code image will be affected after deciding the QR code and creates a problem while using the intact area of the code in which the image or logo is to be embedded. By applying the genetic algorithm, the problems will be rectified and the modified pixels are selected accurately and quickly using halftoning masks as compared to the existing algorithm. It contains several steps to find the modified pixels in QR code embedding process. Using genetic algorithm, embedding the QR code in any color image will take less time. This algorithm can be applied to any color image and QR code with full area coverage and bounded probability of error. The binarization method that contains optimization techniques are used which are designed flexibly for parallel implementation and also reduces the processing time. The process is suitable and straightforward for non technical users also. Lastly the QR images are obtained after retrieving the code at less brightness turbulence.**

***Keywords*-QR code, binarization, embedding, halftoning .**

I. INTRODUCTION

With barcodes, information is coded in one dimension only. Conversely with 2D codes, information is coded in two dimensions: crossways and up/down. A QR code consists of black section (square dots) arranged in a square grid on a white background, which can be read by an imaging devices (such as a camera). A QR code uses four standardized encoding modes (numeric, alphanumeric, byte / binary, and kanji) to proficiently store data. The QR code system was invented in 1994 by Denso Wave. Its purpose was to track vehicles during manufacture; it was designed to allow high-speed component scanning [1]. Maximum storage capacity of QR code is 4296 characters [2] [3].

QR codes originally designed for industrial uses, which have then become common in consumer advertising. Typically, a smart phone is used as a QR code scanner, displaying the code and converting it to some useful form (such as a standard URL for a website, thereby obviating the requirement for a user to type it into a web browser). The QR code has become a focus of advertising strategy, since it provides a way to access a brand's website more quickly than by manually entering a URL[4][5]. Quick response (QR) codes have rapidly materialized as a largely used inventory tracking and identification method in transport, manufacturing, and retail industries. Their popularity is due to the propagation of smart phones, capable of decoding and accessing on line resources as well as its high storage capacity and speed of decoding. QR codes are utilized in a variety of applications, such as accessing websites, download personal card information, post information to social networks, initiate phone calls, reproduce videos or open text documents. This resourcefulness makes them valuable tool in any industry that seeks to connect mobile users from printed materials. QR codes have been widely accepted in the marketing and publicity industry also. The square shapes and limited color tolerance severely impairs their assimilation into billboard designs or printed materials. This challenge has generated great interest for algorithms capable of embedding QR codes into images without loosing decoding robustness. QR Codes are a very reliable and convenient way to introduce textual information into mobile devices without the hassle of typing complicated chains of characters. A QR code can be read easily as well as being capable of holding a great deal of information. This code could not only hold a great pact of information, but it could also be read more than 10 times faster than other codes.

This paper focuses on the different algorithmic techniques for embedding QR codes into logos or images while maintaining acceptable decoding robustness. In contrast to prior approaches the methods presented here allows embedding the QR code into color images automatically with bounded probability of detection error and least interference of the user. These embeddings are designed to be well-matched with standard decoding applications and can be applied to any color image with full area coverage. The embedding problem will be solved by the integration of different halftoning and visual quality assessment techniques with numerical optimizations. The algorithm used for embedding is quite simple, consisting of the modification of the luminance from a group of pixels in each QR code module. These pixels are selected by thresholding a halftoning mask for the case of constant tone images. In [6] genetic optimization algorithm is used to select the angle, size and position of the logo to be inserted by maximizing the probability of correct decoding with multiple QR readers. The algorithm utilizes masks for the selection of modified pixels. The methods presented in [6] [7] involves the strategy on finding the best group of QR modules to substitute by the image or logo. The second category of QR embedding algorithm is based on the modification of the luminance of individual pixels without shifting the location of QR modules. The approach in [8] is based on a method where the luminance of the image is changed according to the code structure. The visual quality is improved by altering the luminance at the center of each QR module according to its value while the remaining pixels in the module are less distorted. Luminance modification algorithm introduces distortions, altering the binarization thresholds and thus increasing the probability of detection error. Another challenge concerns the problem of using the entire area of the code in which the image or logo is to be embedded. To achieve the maximum possible quality, the embedding method must take into account the binarization process and in particular the threshold calculation process which has been largely overlooked by earlier embedding methods.

II. QR CODE PATTERN & STRUCTURE

The patterns and structures contained by a QR code have well defined functions which include symbol alignment, sampling grid determination, and error correction. These patterns are used in the decoding process, to extract the QR code image [9] [10].The information is encoded in square black and white modules of several pixels extensive. The modules in a QR code can be classified in two major categories: function pattern region and encoding region.

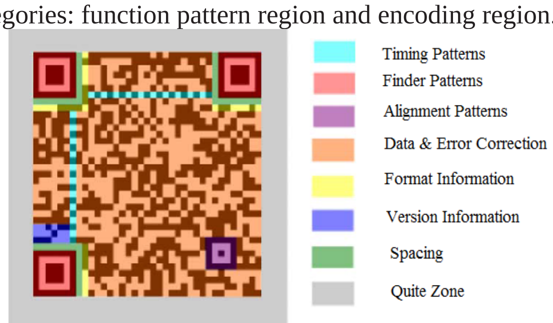

Fig. 1. QR Code Regions [11]

A. Function Pattern Region

The function pattern region comprises of the finder and alignment patterns as well as the timing patterns. These regions contain all the essential information to successfully detect and sample the information bits of the code. Finder and alignment patterns are the most crucial modules in the region and are means to locate, rotate and align the QR code. Finder patterns are surrounded by two guard zones of one QR 10 module wide called the separators [10] [12]. Alignment patterns on the other hand are used to determine the sampling grids from which code words are extracted and to correct for possible deformation of the printing surface [12].

B. Encoding Region

The encoding region includes the information code words, the error correction code words and the modules used for the determination of the version and type of encoded data. The code area encircled by finder patterns is denoted as the encoding region, where data, parity modules and decoding information is stored. This region also contains version and format modules that carry information about the data type stored in the code as well as its expected size.

This paper presents the QR code embedding methods which encodes the information bits into the luminance values of the image in such a way that the average luminance is increased for light regions in the code and decreased for dark regions. The first is the use of halftoning techniques to select the set of modified pixels and split or attenuate the coarse square structures of QR modules and the second is the optimization of the luminance and deliberation of modified pixels in local neighborhoods. Different luminance modification and pixel selection strategies are proposed depending on the type of image to be embedded and the level of robustness desired.

C. Halftoning Techniques

Halftoning techniques [13] are used in order to minimize the appearance of blocks while preserving the high frequency details. If modified pixels are randomly but uniformly distributed in space, the visual impact of the embedding is minimized since these patterns concentrate most of their energy at higher frequencies where the human visual system is less sensitive. This effect is commonly used in digital halftoning [14] where different algorithms are presented to generate even distributions of points with particular spectral properties which have been proposed. [13]

D. Luminance Modification

Once the pixels are selected, its luminance is modified to one out of four possible levels $\alpha, \beta, \alpha c, \beta c$. The binarization thresholds depend on the luminance of all the pixels in a local window. An embedding method should take this into account and define the luminance modifications accordingly. The levels α, β correspond to the luminance of a black image dot into a dark or light QR code region respectively while αc, βc correspond to white image pixels in a dark or light QR region. The last two luminance levels $\alpha 0, \beta 0$ correspond to the pixels at the center of each QR module, and their values are assigned only as a function of the QR code value. [7]

A block diagram of the embedding process in QR codes is described in Fig. 2. The inputs provided are the original image, the QR code, the halftone mask and the masks used for image prioritization and global value.

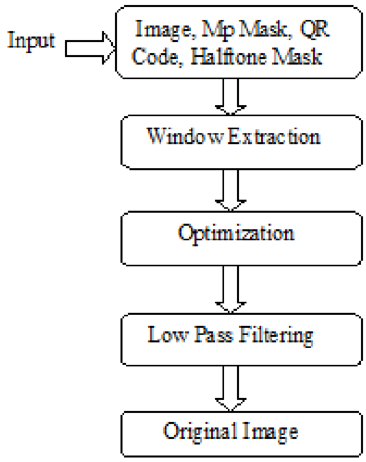

Fig. 2 Different steps of the QR code embedding procedure.

These images are separated in local windows and then optimized separately and in parallel. After the primary subdivision of the image, the code and the different masks into blocks, the optimization of each window of blocks is carried out in parallel. The Genetic algorithm is used in optimization process to come across the correct value by using mutation method. The algorithm proposed selects the modified pixels exactly and quickly compared to the existing algorithm. The global luminance parameters are achieved by combining the local optimums and then this global map is applied to the image. The combination of the global luminance parameters is done by low pass filtering the array of solutions and interpolating to match the size of the original image. This global map is then applied to the original image to get the QR embedding. By performing the optimization parallely and then after combining the results, the speed of the embedding will be greatly increased.

CONCLUSION

In the QR code embedding process, the code image will be affected after deciding the QR code and creates a problem while using the entire area of the code in which the image or logo is to be embedded. The main challenge of any embedding method is that they should be decodable by the standard applications. A good embedding method should minimize the number of corrupted modules and use the greatest possible area. The focus of this paper is to introduce a novel technique to distribute modified pixels based on halftoning methods which help to reduce the visual impact of the modification and to achieve above goals. The algorithm used can be applied to any color image and QR code with full area coverage and bounded probability of error. In addition to the use of halftones to reduce the visual distortion of the embedding, the method presented, defines a quality metric which considers color, tone and structural similarity which is used to select the optimal luminance of modified pixels.

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