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Implementation of QR Code by Image Embedding Using Genetic Algorithm

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Abstract: QR (Quick Response) code is a popular form of barcode pattern that is universally used to tag information to products or for linking advertisements, but the bar code readable by the optical machine. QR codes frequently take up a non-negligible presentation area; there is a growing demand for fabricating visually appealing QR codes. Such codes that incorporate high-level visual features such as colors, letters, illustrations, or logos. By embedding the (QR) code in image having the full area coverage surely maximize the visual quality means low image distortion and decoding robustness. The process is suitable and easy made for non-technical users also. By applying the genetic algorithm for optimization in the embedding process will take less processing time. The algorithm projected here is based on the selection of a set of modified pixels using a halftoning mask. Also the embedding process presented in this paper is based on two components, first is halftoning technique and second one is the modification of luminance level. A quality metric, mean squared error of human visual system is used to measure image similarity.

Keywords: QR code, embedding, halftoning, luminance, optimization, image distortion, genetic algorithm.

1. Introduction

QR Code is a two dimensional bar code that is, in the form of the matrix Code. A QR code consists of black section (square dots) arranged in a square grid on a white background. A QR code uses four standardized encoding modes (numeric, alphanumeric, byte / binary, and kanji) to proficiently store data. The QR Code has several advantages over the one dimensional bar code, as are more sensitive than the QR Code. QR code can hold more data. More complex a problem is, the higher the difficulty of obtaining the optimum solution. 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].

The inventions of the design QR codes can be generally classified into two types. Some intentionally modify several bits of an original QR code within the possible the error correction capability, and the others change the padding symbols to produce a specific designed image on the QR code. However, the exploitation of the error correction capability for design degrades the readability of the design QR codes, and the possible area in which the designed image is embedded is restricted due to the standardized structure of QR code. [4]

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 [5][6].

This paper focuses on the different algorithmic techniques for embedding QR codes into logos or images while maintaining acceptable decoding robustness. 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 [7] 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 [7] [8] involves the strategy on finding the best group of QR modules to substitute by the image or logo.

2. QR Code Pattern and 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 Structure

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] [11]. 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 [11]. The standard also defines two zones consisting on one row and one column of alternating black and white QR modules, denoted as the timing zones and located between finder patterns. These patterns aid in the determination of the sampling grid and the correction for perspective transformation in conjunction with alignment patterns. [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. The table I shows the storage capacity of QR code as per the type of data used.

TABLE I
Storage Capacity of QR code

QR Code Data Capacity	
Numeric only	Max 7,089 characters
Alphanumeric	Max 4,296 characters
Binary(8 bits)	Max 2,953 characters
Kanji	Max 1,817 characters

3. IMAGE EMBEDDING TECHNIQUES

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.

A. 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].

B. Luminance Modification

After selecting the pixels, its luminance is modified to one of four possible levels α, β, αc, βc. This transformation changes the luminance of the pixels that are selected according to the halftone distribution and keep the remaining pixels in the image unchanged. The pixels at the center of the QR module are assigned different luminance levels, since they play a central role in the detection of binary values when the sampling accuracy is high. [7]

4. EMBEDDING PROCEDURE

In the image embedding procedure inputs are the original image and the QR code. The initial image that could be a color image for which RGB values are calculated and mean intensity and entropy is additionally calculated thus to match with the resultant image when embedding. Next step is masking during which constituent modification is administrated and image is split into blocks of modules. If the proper features of an image are chosen and processed at the proper levels then extraneous information is discarded to decrease the scale of the image whereas raising its quality. The colour image is regenerated to binary image thus to match the luminance values of QR code. QR embedding technique converts the data bits of the input QR code image into the luminance values of the image as a result of this average luminance is enhanced for light regions within the code and decreased for dark regions. The average luminance is calculated using following equation number 1.

$$Tm,n= \frac{1}{25\times 64} \;\sum_{p=n-2}^{q=n+2} \sum_{p=m-2}^{p=m+2} \sum_{(k,1)\in\beta(p,q)} Y[k,k] \text{ ....eq no. 1}$$

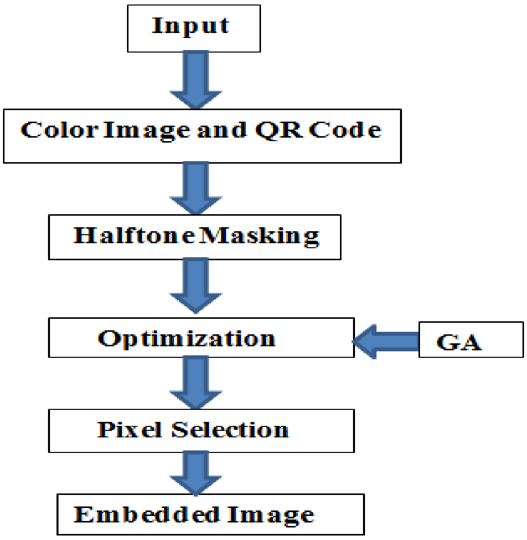

Fig. 2 Image Embedding Procedure in QR Codes

These images are then separated in native windows so optimized singly and in parallel. After the subdivision of the image, the code and the different masks into blocks, the optimization of every window of blocks is administrated independently. In this step genetic algorithm precisely for optimization that selects the modified pixels exactly and quickly compared to the prevailing algorithm. The global luminance parameters are achieved by combining the native optimums. The combination of the global luminance parameters is performed by low pass filtering the array of solutions and interpolating to match the scale of the first image. This global map is then applied to the first image to get the QR embedding.

5. Result and Discussion

Image embedding provides an efficient technique to modify comparison and analysis of data having complementary information regarding the contained region. Image embedding creates new images that are more appropriate for the needs of human/machine perception and for additional image processing tasks. The figure number 3 shows the result and also the actual procedure performed as per the objective. The input is taken in the form of gray scale image and QR code, then masking of both the images is carried out.

Fig. 3 Steps Followed in Image Embedding

The second step of above figure shows the result after masking. Then optimization is performed for which genetic algorithm is used. Parameters are used in genetic algorithm for optimization of fitness function. Then resultant image after embedding is shown in the last step.

Steps Performed by Genetic Algorithm

1) Choose parameter to optimize.
2) Determine chromosomal representation of parameters
3) Generate initial population of individuals.
4) Evaluate fitness of each individual to reproduce.
5) Allow selection rules and random behavior to select next population.

Genetic algorithm uses probabilistic transition rules instead of settled rules, and handles a population of candidate solutions (called individuals or chromosomes) that progresses iteratively. Each iteration of the algorithm is identified as generation. The evolution of the species is simulated through a fitness function and a couple of genetic operators like reproduction, crossover and mutation.

Each candidate solution contains a set of properties which may be mutated and altered; historically, solutions are delineated in binary as strings of 0s and 1s.

The new population is employed within the next iteration of the algorithm. The algorithm terminates when either a most variety of generations has been created, or a satisfactory fitness level has been reached for the population. Next step to the optimization is pixel selection. The pixel regions within the specific range were identified as the selected pixels which are based on Genetic algorithm. Distinction between the pixels in the QR module is carried out which helps in the decoding of the pixel values. The masking process is serviced which is based on the user specified range for masking of the pixels.

In the table number 2 entropy of the embedded image is also calculated for showing that when the image will be decoded the entire original message is obtained. The time taken for optimization is shown in the following table which is 32 sec on an average.

TABLE II
Calculation of Entropy & Optimization Time

Sr. No	Image Dimensions	Entropy	Optimization Time(sec)
1.	200×200	0.98473	29.1058
2.	225×225	0.98549	37.9174
3.	232×232	0.98462	41.7284

A quality metric, mean square error of human visual system is employed to measure image similarity. If the MSE is nearer to zero then visual distortion are going to be minimum. Table number 3 shows the time required for embedding which is minimum and MSE value is also minimum indicates that original image is obtained with minimum distortion.

TABLE III
Calculation of MSE for Different Image Sizes

Sr. No	Image Dimensions	MSE Value	Embedding Time(sec)
1.	200×200	0.1598	9.1153
2.	225×225	0.1937	9.1623
3.	232×232	0.2239	9.5156

By performing the optimization parallely and so when combining the results, the speed of the embedding are going to be greatly increased.

6. Conclusion

This paper presents a genetic algorithm to create a new type of visual QR code, called halftone QR code, at a controllable level of readability.

The focus of this paper is to introduce a novel technique to distribute modified pixels based on halftoning methods which helps to reduce the visual impact of the modification. The algorithm used can be applied to any color image and QR code with full area coverage. The process is easy made for non-technical users also. By applying the genetic algorithm for optimization in the embedding process will take less processing time. Also the image obtained after embedding the QR code with low distortion and good visual quality.

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