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PROGRESSION OF NOVEL OPTIMIZED COLOR IMAGE TECHNIQUE FOR QUICK RESPONSE CODES

Subtitle:An optimized image embedding process in color QR code

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ABSTRACT*: The developed system makes use of QR codes that is embedded in the color image using DWT (Discrete Wavelet Transform), an automatic method to embed color QR codes into color images with bounded probability of detection error. Here we develop cyan (c), magenta (m), and yellow (y) print colorant channels based three unique QR codes commonly used for color printing and the complementary red (r), green (g), and blue (b) channels, respectively, used for capturing color images. These embeddings are compatible with standard decoding applications. Experimental results show the graceful degradation of the decoding rate and the perceptual quality as a function of the embedding parameters.*

Keywords: *Color QR Code, Image Embedding, Halftoning, DWT.*

I. INTRODUCTION

Quick Response (QR) codes [1], [4] are versatile. A piece of long multilingual text, a linked URL, an automated SMS message, a business card or just about any information can be embedded into the two-dimensional barcode. Coupled with moderate equipped mobile devices, QR Codes can connect the users to the information quickly and easily. In this paper, we explore how QR codes can be used to stored large data. A QR code is capable of holding 7,089 numeric characters, 4,296 alphanumeric characters, 2,953 binary bytes, 1,817 Kanji characters or a mixture of them. The data capacity is much higher than other 2D codes such as PDF417, Data Matrix and Maxi Code (Denso, 2010b). It stores information in both vertical and horizontal directions. A QR code can be read from any direction in 360° through position detection patterns located at the three corners of the QR code.

A QR code can be read even it is somewhat distorted by either being tilted or on a curved surface by alignment patterns and timing patterns [2]. The error correction capability against dirt and damage can be up to 30%. A linking functionality is possible for a QR code to be represented by up to 16 QR codes at maximum so that a small printing space is possible. The size of a QR code can vary from 21x21 cells to 177x177 cells by 4 cell increments in both horizontal and vertical direction. Data can be easily encrypted in a QR code to provide a confidentiality of information embedded in the code. It can also handle various languages. For examples, there are a number of standards adopted by Asian countries like GB/T 18284 by Chinese National Standard in 2000, KS-X ISO/IEC 18004 by Korean National Standard in 2002, and TCVN7322 by Vietnam National Standard in 2003.these standards are well explained in Quick Response concept.

II. DATA ENCODING

A. QR CODE: QR code (Quick Response Code) is the trademark for a type of two-dimensional barcode. A barcode is optically machine readable and is attached to an item that records relevant information [4], [14]. The information encoded by a QR code may be made up of four standardized types ("modes") of data (numeric, alphanumeric, byte / binary, Kanji) or, through supported extensions, virtually any type of data [7]. The QR Code system has become popular outside the automotive industry due to its fast readability and greater storage capacity compared to standard UPC barcodes. Applications include product tracking, data base maintenance, item identification, time tracking, document management, general marketing, and much more.

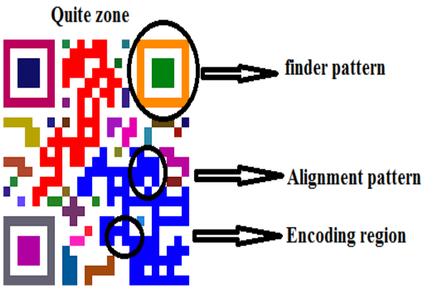


Fig 1. Quick response (QR) Code

Function Pattern Region: Finder and alignment structures are essential to locate, rotate and align the QR code. The former ones are designed to have the same ratio of black and white pixels when intersected by a line at any angle, allowing to easily detecting rotated or inverted codes. Alignment patterns are used to determine the sampling grids from which codeword's are extracted and they are easily identifiable as concentric square structures evenly distributed along the code area.

Encoding Region: The code area delimited by finder Patterns are denoted as the encoding region where data, parity modules and decoding information is stored. This area is divided into code word's consisting of blocks of 8 QR modules.

Data Capacity and Error Correction: Different types of QR codes defined in the standard are identified by their version and error correction level. The version of the QR code determines its size and goes from 21×21 modules for version 1 up to 177×177 for version 40. QR codes use Reed Solomon code for error correction and there are 4 types of error correction L, M, Q and H that allow correcting up to 7%, 15%, 20% and 30% of codeword's in error respectively.

B. QR CODE GENERATION

The movement of using QR codes in education is still in its infancy. We have only a few examples which can be drawn from the literature as described below:

1. For each catalogue search at the library of the University, a QR code will also be displayed automatically to summarize the key information, the title, the author, and the shelf location as shown in Fig 2.

2. Student assignment submission to the Faculty of Engineering. QR codes are automatically added to the bottom of Moodle print outs. The QR code contains the URL of the page on that particular Moodle course.

3. QR codes can also be found on posters around campus, on Websites and service blogs for bookmarking, in handbooks linking to activities, and in marketing materials from departments. Here the input data's are converted into ASCII conversion block also the select the mode, after that ASCII values are divided into groups with two elements. These elements are group into 11 bit conversion .That bit stream are converted into block [10], [13]. After that we can add mode indicator and character count indicator for further processing these are very useful to generate the QR code. Finally we select the pattern size for review process then decode the original data.

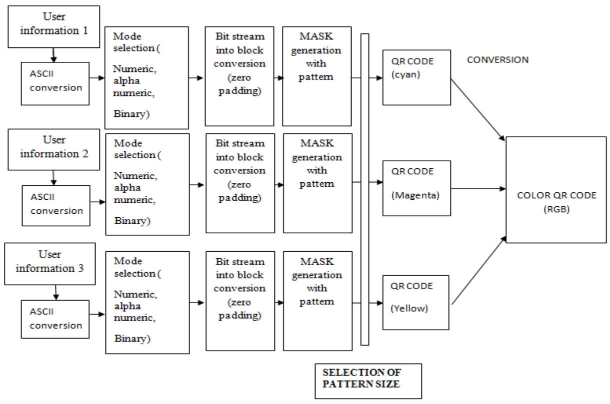


Fig. 2 QR code generation

C. DATA ENCODING ALGORITHM

Step 1: Choose the error correction level.
Step 2: Determine the smallest version for the data
How to determine the smallest version
Upper limits.
Step 3: Add the mode indicator.
Step 4: Add the character count indicator
Versions 1 through 9
Versions 10 through 26
Versions 27 through 40
Step 5: Encode using the selected mode.
Step 6: Break up into 8-bit codeword's.
Step 7: Determine the required number of bits.
Step 8: Add a terminator of 0s if Necessary.
Step 9: Add more 0s to make the length a multiple of 8.
Step 10: Add pad bytes if the string is still too short.

Example of selection mode process:

Encoding the data is "**HELLO WORLD**"

1. Breakup into pair (i.e.) HE, LL, O, WO, RL, D
2. First we take the first pair then take decimal value
(i.e.) H-17and E-14.

3. These values are multiplied by 45 (i.e.)
   (45*17)+14=779.
4. Binary conversion (i.e.) 779-0110000101101.
5. That binary value is converted to pattern.

III. EMBEDDING PROCESS

The main challenge of any embedding method is the fact that they should be decodable by standard applications and can be applied to any color image with full area coverage [6], [11], [17]. In this project we are using the input image was Lena image. In this embedding for long visibility we can see the Lena image inside the QR code. But in close vision we can see only the pattern of the QR code. The embedding of image pixels introduces changes in the luminance of the code, distorting the binarization thresholds. The challenge concerns the problem of using the entire area of the code in which the image or logo is to be embedded [15]. This cannot be achieved by simply replacing information modules with the desired image since the number of modules that can be replaced is at most proportional to the correction capacity of the code is shown in fig 3.

A good embedding method should minimize the number of corrupted modules and possible area while keeping visual fidelity to the original image [17]. The section of QR Code, analyze the entire input data stream to identify the characters to be encoded. QR Code supports the extended Channel interpretation feature. For the case of halftones the most commonly used metric is based on the MSE between two filtered versions of the original image and the halftone where the filter usually models the low pass characteristic of the HVS.

The embeddings with smaller center regions where more susceptible to error and the Scanning distance limited to 1 or 2 inches around the distance in which a QR module pixel is represented by a pixel in the captured image. A method which implements a similar idea is Logo [13].

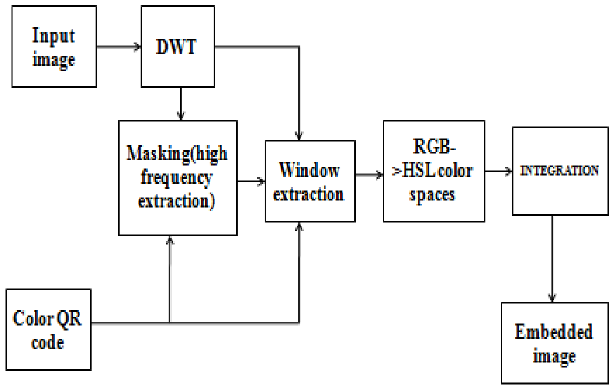


Fig. 3. Embedding Process of Image using DWT

A. DISCRETE WAVELET TRANSFORM

Based on the image decomposition model of wavelet transform, the original image can be divided into low frequency information and high-frequency information [5]. After two-dimensional frequency decomposition of wavelet transform, low frequency information can be further decomposed to low-frequency area LL and high-frequency area LH. Similarly, high frequency information can be decomposed to low frequency area HL and high frequency area HH. Here the relevant information's are stored in LL part.

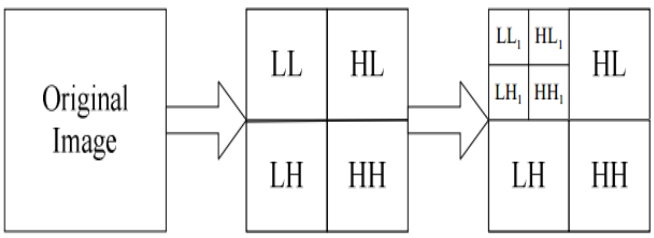


Fig. 4 Wavelet Transform based Image Decomposition

Generally, the idea of edge detection using wavelet transform is described as below, Choose a suitable wavelet function. Use the function to transform images into decomposition levels [5], [19]. Detect the edges from the filtered detailed coefficients. This embedding process gives embedding color image with color QR code. The decomposition of image used to select the portion of multi resolution data. That data is used to recover the original image

B. PARAMETER OPTIMIZATION

In order to take advantage of local correlations between the luminance of the image [16] and the values of the QR code, the optimization of the transformation parameters is performed independently using local overlapping windows. In our implementation we choose to set the size of the windows to 40×40 pixels centered on each image block of 8×8 pixels. A block diagram of the optimization process is depicted in Fig. 4. After the initial subdivision of the image, the code and the optimization of each window is performed in parallel. The combination of the global luminance parameters is performed by low pass filtering the array of solutions and interpolating to match the size of the original image [11]. This global map is then applied to the original image to obtain the QR code input image embedding after we got parameter of different logos in table 1.

III. DEVELOPMENT OF QR CODE

The decoding process continues with three basic stages: binarization, detection, and decoding of the bit stream.

A. BINARIZATION

A salient feature of QR codes which plays a central role.In their decoding speed is the use of binarization as the first step in the decoding process. Binary images are

obtained by thresholding the gray scale image as

$$IB\,[i,j] = \begin{cases} 1 \text{ if } Y_{i,j} > t_{i,j} \\ 0 \text{ If } Y_{i,j} \le t_{i,j} \end{cases}$$

Where Y is the image captured by the camera, $t_{i,j}$ is the Threshold assigned to pixel [i, j] and IB [i, j] is the binary output.

B. HALFTONING TECHNIQUES

The method proposed to select modified pixels is based on half toning techniques in order to minimize the appearance of blocks while preserving high frequency details [4] and [6]. 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.

C. LUMINANCE MODIFICATION

After selecting the pixels, its luminance is modified to one of four possible levels α, β, α_c, β_c. The luminance of the embedded image Y out i, j at (i, j) is selected as a function of the QR code value $q_{i,j}$ and the luminance of the original image $Y_{i,j}$ as denoted in below equation 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 [4]. The pixels at the center of the QR modules are assigned different luminance levels, since they play a central role in the detection of binary values when the sampling accuracy is high.

$$Y_{out} = \begin{cases} \beta & \text{if } M_{i,j} = 0,\ q_{i,j} = 1,\ Ipc,\ (i,j) = 1 \\ A & \text{if } M_{i,j} = 0,\ q_{i,j} = 0,\ Ipc,\ (i,j) = 1 \\ Bc & \text{if } M_{i,j} = 1,\ q_{i,j} = 1 \\ Ac & \text{if } M_{i,j} = 1,\ q_{i,j} = 0 \end{cases}$$

D. COLOR OPTIMIZATION

Since the goal is to embed the codes into color images, we need to establish a rule to select the corresponding color vector for each modified luminance since there is an associated subspace of colors in the RGB space for each luminance value [4], [21]. To determine the best possible color that fulfills the luminance constraint, it is necessary to measure the color differences into a perceptually uniform color space the relationship between the luminance defined as

$$\mathbf{Y = 0.2989R + 0.5870G + 0.114B} \text{ and}$$

$$\mathbf{L = min(R, G, B) + max(R, G, B)}$$

Linear and monotone function Y = f (L). If the weight luminance vector is defined as

$$\mathbf{w = [0.298, 0.587, 0.1140]^T,}$$

Then f (L) is given by,

$$\mathbf{Y = f\,(L) = w^T\, T^{-1}\,(H, S, L)}$$

$$\text{Where} \quad \mathbf{L^* = \arg\min L|f\,(L) - l_t|}$$

Where (R, G, B) = T^{-1} (H, S, L) is the backward transformation from HSL to RGB color spaces. Once the optimal value L^* is determined, the new RGB components of the pixels are obtained by using the forward transformation between the HSL and RGB color spaces (R*, G*, B*) = T^{-1} (H, S, L) Summarizing the different steps, the transformations to obtain the *RGB* value of a modified pixel, given the target luminance value l_t

IV. SIMULATION OUTPUT

A QR code image, of size 21x21 pixel was used for the experiment in fig 5.

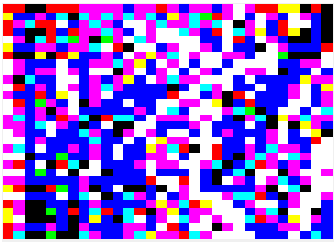


Fig. 5 Substitutions of QR modules by a logo

It is important to note that the embedding method might fail to decode if the reading application uses a different binarization method than the one assumed here however since the Zxing library is widely adopted this is not a severe limitation. Here the input logo (Lena image) is embedded with inside the QR code. In this embedding for long visibility we can see the Lena image inside the QR code. But in close vision we can see only the pattern of the QR code.

Finally the present implementation in Mat lab takes 30 minutes to optimize a color image of size 350×350 pixels, but more efficient implementations take advantage of parallelism and especial processors like GPUs might reduce the optimization time to practical Levels. This code will be scanned both horizontal and vertical direction with full area coverage. This feature also allows solving the problem of dot gain generated when the embeddings are printed simply by using appropriate half toning masks.

A.PEFORMANCE ANLAYZES OUTPUT

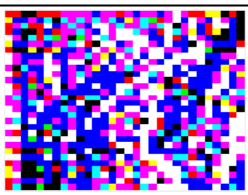
In this last stage, QR code is extracted from the color image. As QR code handles 30% error correction levels. There are four levels of error correction process in QR code. When QR code is decoded from the color image, the luminance of the QR code is reduced due to this the distortion in the QR code can be measured using Mean Square Error (MSE), Structural Similarity Index Measure (SSIM) and Peak Signal to Noise Ratio (PSNR).Here the different image hidden technique using color QR code. Normally the image having some parameter, here the Comparison of different logo embedding parameters is given below,

Input image	PSNR	MSE	SSIM
Butterfly logo	57.1093	0.0968	0.9829
Circle logo	55.5419	0.0609	0.9847
Company logo	59.9346	0.0216	0.9950
Lena image	53.8215	0.1200	0.9888
College logo	56.9614	0.0567	0.9921

Table 1 Image Parameter

An interesting feature of the proposed embedding method is the possibility to generate embeddings with different textures by changing the halftone mask as in Table 2 where a clustered dot mask aligned with the center of the QR modules was used generating pseudo random cluster of dots. This feature also allow to solving the problem of dot gain generated when the embeddings are printed simply by using appropriate half toning masks.

B. CASE STUDY

QR Pattern	Interpretation
	In this pattern the original image is embedded inside the QR pattern.
	In this pattern the college logo is embedded inside the QR pattern.

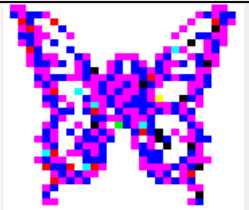
	In this pattern the butterfly image is embedded inside the QR pattern.
	In this pattern the circle image is embedded inside the QR pattern.
	In this pattern the Company image is embedded inside the QR pattern.

Table 2 Embedding Images of QR codes

C. FUTURE WORK

We are going to introduce the concept of color QR images, an automatic method to embed color QR codes into color images with bounded probability of detection error. Here we develop cyan (C), magenta (M), and yellow (Y) print colorant channels based three unique QR codes commonly used for color printing and the complementary red (R), green (G), and blue (B) channels, respectively, used for capturing color images. And finally we embed with color images. As the mobile phone with camera device is getting more popular, recognition barcode based on embedded system is getting more important and practical. We are going to propose a new high-speed, high-accuracy automatic FPGA based method for generating QR Code for various text sizes. The FPGA configuration is generally specified using a hardware description language (HDL), similar to that used for an application-specific integrated circuit.

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