

An Optimized Image and Data Embedding in Color QR Code

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Abstract: The main motto of this project is to generate color QR(quick response) code, which is a 2D barcode where the information are embedded in both horizontal and in vertical directions, while embedding the information in QR image , it causes a blurring effect which reduces the aestheticism and also makes it difficult to decode data at the receiver end. To avoid this ,QR image is embedded in HF(High Frequency) cover image in various novelty technique, The HF of cover image can be obtained using DWT(Discrete Wavelet Transform) by applying the combinations of low pass, high pass filters. Whereas, in this paper a reinforced technique is implemented by embedding series of image instead single image. Thereby this technique improves the storage area and resolution of QR image and also it assures security policy.

Key words: Color QR codes • Halftoning • Aesthetic • Reed-Solomon codes • Video embedding

INTRODUCTION

QR code is a matrix barcode which is used for accommodating extra number of data than its 1D counterpart. QR code has the capability of correcting errors since reed Solomon(RS) code have already been incorporated in it. It is an extensively utilized pursuing and identification method in transport, production and in retail industries. QR codes are highly popular of their high storage capacity and speed of decoding. They are used in collection of requests such as accessing websites, download confidential card data, post data to communal webs, replicate videos or open text documents. This versatility makes them a priceless instrument in each industry that seeks to involve mobile users from printed materials. QR code decoding is done based on the visual appearance which avoids the additional hardware requirement. Earlier the decoding methods of binary QR codes were the Sylvester resultant or grobner basis methods [1, 2, 3].

QR code design is highly based on machine readable format thereby it encounters noisy patterns. The noise like patterns of QR code causes visual disturbances when put in to the host materials like posters directly. QR code is decoded based on appearance, Hence the design of QR code with visual

pleasant appearance along with the accuracy of decoded message becomes a major challenge. One of the common approaches enforced the QR design on embedding icon directly. This approach introduces invalid code words in the resultant QR codes where the changeable area is bounded by error capability, that is the maximum area is usually less than 30% of the whole QR area [4, 5]. In order to deal with this problem appearance based QR code beautifier is proposed [6]. This work involves the embedment of visual pleasant images in to QR codes without violating the specification for decoding. This approach eliminates the drawback of visual imbalance but the storage capacity is less [6]. Hence to improvise the storage capacity a color QR code generation is proposed, where in this paper the visual pleasant appearance along with storage space is taken in to consideration. This paper will demonstrate that the proposed scheme achieves largest changeable area as compared with existing approaches.

The paper is structured as follows primarily, the background along with its encoding flowchart is introduced in section-II. Next in section III Generation of color QR code is reviewed. The proposed technique on embedment of data on color QR code is detailed in section IV. section V presents the experimental results and corresponding evaluations. Finally, section VI concludes this work.

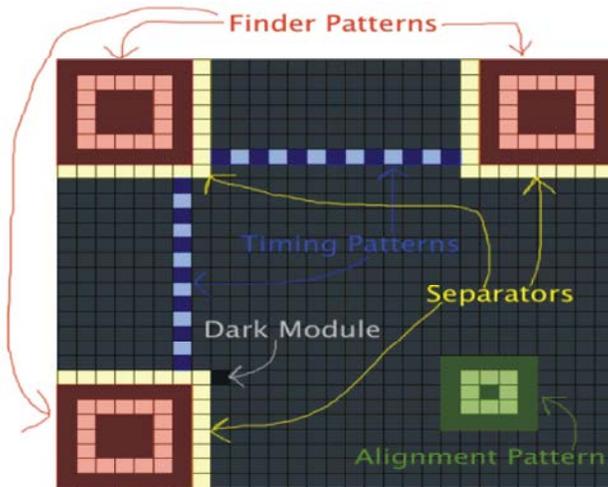


Fig. 1: The descriptions and locations of function patterns of a standard QR code

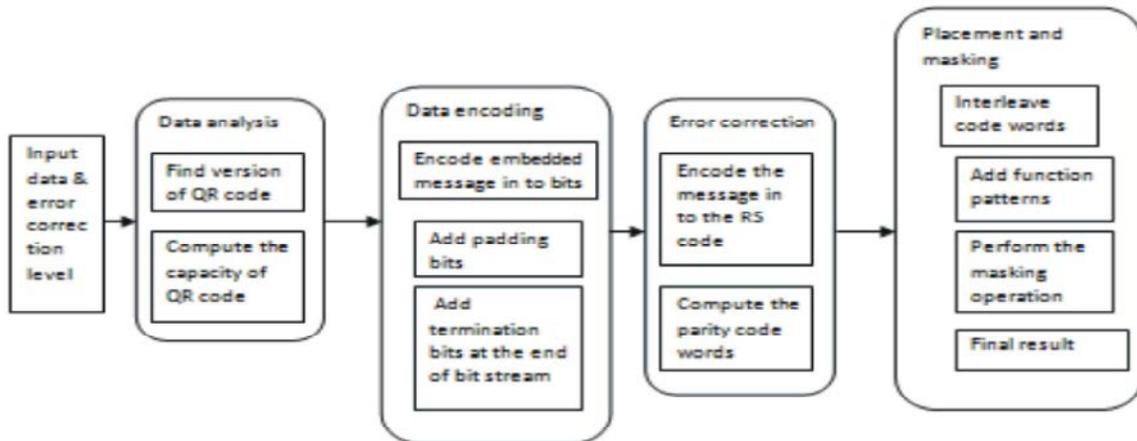


Fig. 2: Block diagram for generation of QR code

Table 1: Error Tolerance Table

Error level	Data recovery
Low	7%
Medium	15%
Quarter	25%
High	30%

Qr Code Generation: QR code is a 2D barcode comprising of smallest black and white squares known as modules. Codeword of QR code is 8bits and each module represents 1bit where white represents logic 0 and black represents logic 1. There are around 40 versions of QR code. Determination of QR code is based on version number V , $V \leq 40$ which relates to the size of $(17+4V) \times (17+4V)$

Structure of Qr Code: QR code consists of finder pattern, alignment pattern, Timing pattern, format information area, version information area is depicted in Fig. 1. Finder pattern is used to detect the position of QR

code. The finder pattern, timing pattern, alignment pattern are the function patterns of QR code. Timing pattern is used to denote the time of data embedding. Alignment pattern in QR code is to determine how the QR code is aligned to store information. The other region is used to store data and error correction code words.

Error Correction Technique: QR code makes use of reed Solomon (RS) code. There are four error correction tolerance levels as shown in Table 1. i.e., low, medium, quarter and high. Low tolerance level QR code is capable of recovering 7% of data, similarly Medium recovers 15%, Quarter level recovers 25% of data, High level recovers 30% of data. The tolerance level is selected based on size and version of QR code QR code with largest version can use 30% tolerance level RS code.

Steps to Generate Binary Qr Code: Flow chart for generation of binary QR code is depicted in Fig. 2.

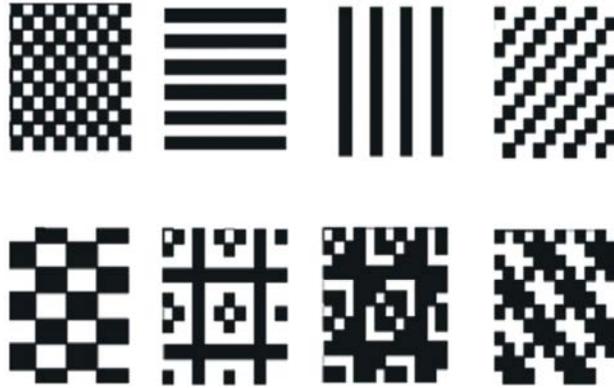


Fig. 3: Masking Patterns for different error correction code

Table 2: Experimental Results about the Impact of Table-ii Different Qr Code Sizes and Embedded Messages Amounts

QR Code	Embedded Message (% of total capacity)	Time (sec)	Number of early converged codewords	Distortion in (salient, whole) regions (%)
(15,L)	5	35.07	0	(0.96, 33.60)
	20	35.4	1	(1.90, 34.16)
(25,L)	5	141.63	0	(0.56, 33.50)
	20	98.48	2	(1.67, 36.60)
(35,L)	5	224.24	0	(0.33, 33.44)
	20	220.66	3	(1.26, 36.84)
(15,H)	5	44.68	1	(25.07, 44.02)
	20	34.64	4	(25.87, 46.20)
(25,H)	5	176.31	2	(25.84, 43.80)
	20	153.13	7	(28.93, 46.11)
(35,H)	5	326.06	3	(27.37, 43.90)
	20	279.59	13	(29.91, 45.86)

Data Analysis: In this stage, the input data is analysed for compression and also for the determination of error correction level. The suitable version is decided in this stage.

Data Encoding: This stage involves encoding data in a corresponding selected encoding mode. Finally after encoding (0000) terminator bits are added to the end of codeword. If the code words do not reach the capacity of related version of QR code then padding bits are added.

Error Correction Stage: In order to withstand noise during transmission, RS codes are integrated on QR code. RS code is a channel coding technique which is used for noise detection and correction. RS codes can correct burst errors. It is a block coding technique and is represented by (n,k),

where n – length of block code

K – No of code words

The correction level is denoted by t,

$$T = \lfloor (v-k)/2 \rfloor$$

Masking and Placement Stage: There are around 7 to 8 masking patterns for given information and error correction code words. Masking is done mainly to

segregate function patterns from encoded pattern of information. Fig. 3. shows masking patterns that are used in QR code generation [7].

Qr Code Analysis: The experimental results on Table 2 illustrates the QR code size with its data capacity and accuracy of recovery [6].

To examine the impact of QR code configuration on the performance of QR code beautification, the required time complexity and the visual distortion of the proposed algorithm for various QR code configurations (i.e. different settings of QR code with different sizes of embedded messages) are investigated. We increase the size of the embedded message to 5% and 20% of the total information capacity of a given QR code version, evaluate the visual distortion (in terms of Hamming distance) on the salient and the whole regions for each one of the QR codes (from (15,) to (35,)), listed in Table 2. of a QR code. Since the QR codes with higher error correction level (e.g. (15,)) usually have more parity codes than that of QR codes with lower one, the corresponding flexibility for change of the former will be decreased; therefore, the visual appearance will inevitably suffer higher visual distortion (e.g. the visual distortion may go up to 25% of the salient regions) for the QR codes with higher error correction ability. Fig. 4 illustrates two examples of

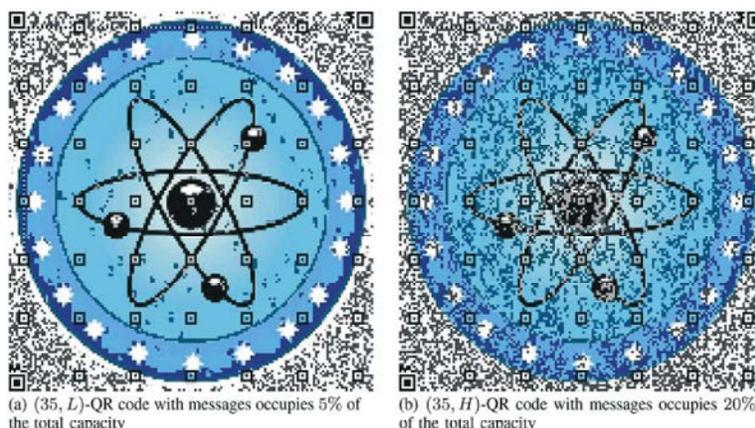


Fig. 4: Beautified QR code with data capacity

large-sized QR codes, where the salient regions (the area of visual pleasing image) occupied about 80% of the entire QR code area.

The required execution time of QR code beautifiers embedded with 20% of the total information capacity is less than that of embedded with 5% counterparts because an early termination condition has been enforced in our approach. The maximum iteration number is set to 1000 initially, we examine the convergence of each codeword based on the corresponding.

Hamming distance and the codeword with converged result (i.e., the corresponding Hamming distance is less than a given threshold or the distance remains the same for a few iterations successively) will be skipped during the computation. The numbers of early converged code words are also listed in Table 2. Notice that the QR codes with higher error correction levels or larger embedded message lengths will have more number of early converged code words. The visual quality (in terms of Hamming distance) of a QR codes embedded with a large-sized message is difficult to be improved, the corresponding visual quality will easily reach to a fixed state and therefore, early terminate the optimization process. QR codes embedded with short URLs will converge quickly, since almost all the area of QR codes are changeable and can be assigned with the visual pleasing images at early stages of optimization. The time complexity and the visual distortion reported in Table 2 can be used as references for users to select proper configurations of the proposed QR code beautification schemes [6].

Generation of Color Qr Code and Embedment of Image Series: 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. These embeddings are compatible with standard decoding applications and can be applied to any color image with full area coverage. The QR information bits are encoded into the luminance values of the image, taking advantage of the immunity of QR readers against local luminance disturbances. To mitigate the visual distortion of the QR image, the algorithm utilizes half toning masks for the selection of modified pixels and nonlinear programming techniques to locally optimize luminance levels. We use a QR code generator to produce a payload (secret message) which is converted to one dimensional vector with a sequence of 1's and 0's. To embed the payload in DWT sub bands (especially the LL sub band), a degradation of the quality of the image is imminent. To increase the QR code efficiency three channels (C,M and Y) are coded as a different patterns represents different information's, the optimization techniques proposed to consider the mechanics of a common binarization method and are designed to be amenable for parallel implementations. Experimental results show the graceful degradation of the decoding rate and the perceptual quality as a function the embedding parameters. The generation of color QR code is summarized in Fig. 5. and the embedment of image series is shown in Fig. 6.

Experimental Results and Evaluations: Fig. 7. shows some of the results obtained from beautification techniques [6]. The same methodology is preferred in this paper alternatively with color QR code by empirically setting the values of $\lambda_1, \lambda_2, \lambda_3$.

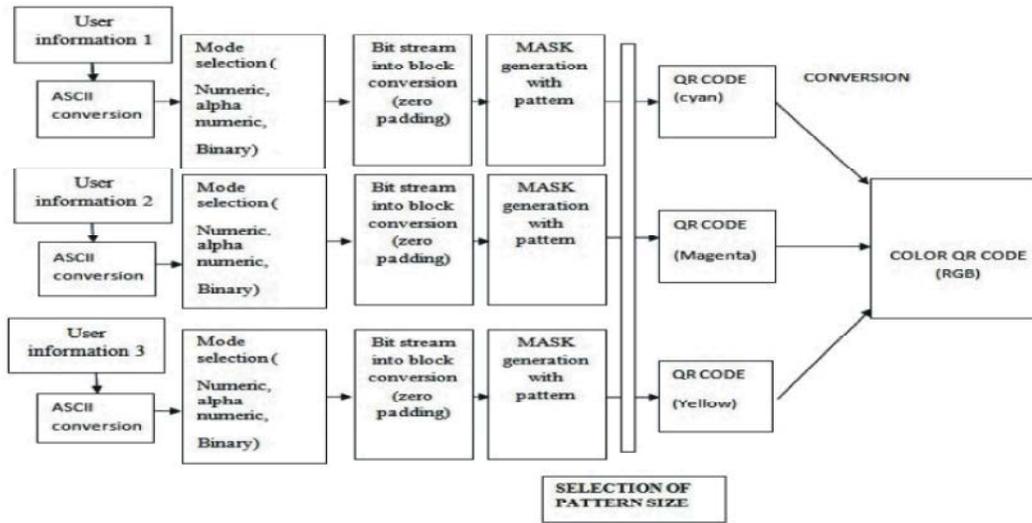


Fig. 5: Color QR code generation

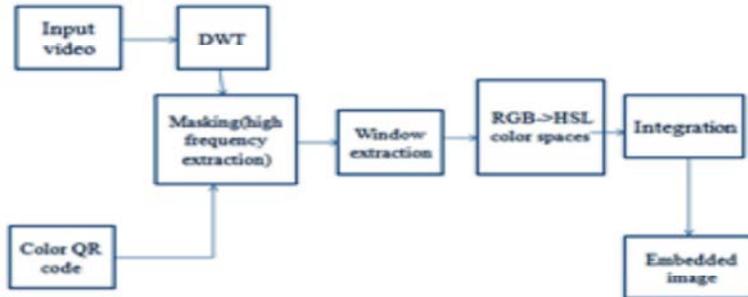


Fig. 6: Block diagram for embedding series image



Fig. 7: QR code before applying beautification technique and after applying beautification technique

Table 3: Analysis of Existing and Proposed Beautification Code for Various Versions

Version(correction level)	Recovery capacity(%)	No. of data code words in existing binary QR code	No. of data code words in proposed colour QR code
(15,J)	7	523	1569
(15,M)	15	415	1245
(15,Q)	25	295	885
(15,H)	30	223	669
(35,L)	7	2306	6918
(35,M)	15	1812	5436
(35,Q)	25	1286	3858
(35,H)	30	996	2988

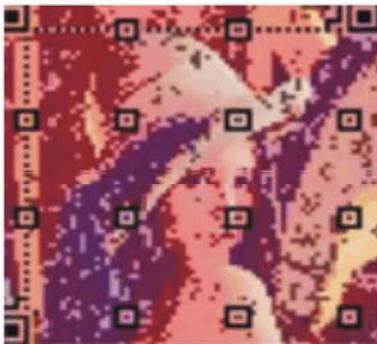


Fig. 8: A. Binary QR image embedment



Fig. 8: B. Color QR image embedment

From Fig. 7. it is clear that when data is decoded from longer distance the error level is high in Binary QR code whereas the error level is reduced by applying beautification technique Hence the recovery of data is high in beautification technique. When accuracy is taken in to account, beautification technique stands erect with high accuracy than Binary QR code. The results of proposed technique proves the idea behind the beautification with the generation of color QR code.

Decoding: Aesthetic Enhancement of QR code: When decoding the information from QR code, it forms a coarse representation. Hence in order to differentiate QR code input image, half toning techniques are preferred.

Half Toning Techniques: It works on dithering concept and plays a vital role representing continuous image in discrete form by calculating the pixel value. The pixel value is represented in dots. By using the dots of corresponding pixels the image embedment is done which makes decoding simpler.

Pixel Selection: Pixel selection in QR code is done at the centre as it has the relevant information for decoding. To accomplish the task of selecting the centre pixel a square mask of size data is selected and the remaining pixels of image are selected by half toning techniques. The centre pixel which are been modified are e embedded on non-centralized pixels by thresholding a green or b blue noise mask resulting in binary pattern with concentration of dots of pixel.

Luminance Enhancement: Luminance is the ability of perception Hence the image transformation is done to classify the priority area of information since the central pixels play a vital role their luminance level is highly concentrated to improve accuracy.

Color Optimization: It highly considers the properties of perception, HSL color space is selected for simpler computation. To determine and obtain the RGB values of central pixel when luminance target L is given $L_{(0,1)}$, the original color is transformed to HSL space and then luminance c component is optimized until the desired level is reached. Fig. 8. depicts the experimental results obtained by embedding image on binary QR code and the results obtained by embedding video on color QR code Color QR code decoding efficiency ranges about 75% while Binary QR code decoding efficiency is 55%. The storage capacity in Color QR code is high since it involves 24 bits per pixel whereas in binary QR code it has 8bits per pixel, so by approximating, the color QR code can hold data in megabytes (MB) and the binary QR code can hold data in kilobytes(KB).

Table 3 shows the capacity of data that can be embedded in Color QR code and binary QR code along with the comparison of various error tolerance levels and its recovery. In this technique it has been proved that the color QR code stores three times of data than the binary QR image. The accuracy of decoding is high in proposed technique than in the existing technique.

CONCLUSION

In this paper, a color QR code beautified frame work is implemented. The work involves the visual saliency considering HSL technique. The binary beautified QR code is compared with beautified color QR code which shows optimized results of improvised storage. This work enhances the aesthetic perception of QR codes for users. This work can extend the usage in authentication field as well in various multimedia application.

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