Proceedings of the International Research Conference of the SLTC Research University, Sri Lanka 2022

Multi-Layered Quick Response Code

Tharka Karunanayake, Eranga Wijebandara, Udesh Oruthota*, Ama Bandara

Faculty of Engineering, Sri Lanka Technological Campus,Padukka Sri Lanka.

udesho@sltc.ac.lk*

Abstract – The quick response code has become more and more prevalent among us, due to their low deployment cost by appearing in leaflets, posters, magazines and other print materials which usually consist with visible black and white modules. The quick response code can be printed in a small space, allowing users to interact with the environment using their smartphone and store more information and data. The problem with the existing model of the code is; lack of security and data capacity. In this paper we provide a solution for the ''data capacity" in quick response codes by enhancing the data storage capacity by using a "weight assigned" algorithm with a multi layered approach. The encoding and decoding process of a layered quick response code is elaborated in detail where it is proved that the proposed algorithm can be extended for 'n' number of layers, while minimizing the marginal error and increasing the number of layers.

Keywords: quick response (QR) code, multi layer, weighted network, data capacity

I. INTRODUCTION

A quick response (QR) code is a two-dimensional (2D) barcode that can be grouped as a matrix with a high number of elements to store data, information based on its allocation capacity. The QR code is well-known for its prominent use in shipment tracking, item labelling, contact information, and ticketing as a user-friendly password mechanism for each environment, since it is served as a creator, allowing information to be decoded quickly. In general, a QR code is made up of two colors, black and white, in a square shape, where the black square represents 1 and the white square represents 0. Both colors black and white in the QR code are allowed to be engaged in the encoding and decoding process to acquire maximum capacity for each character [1, 2].

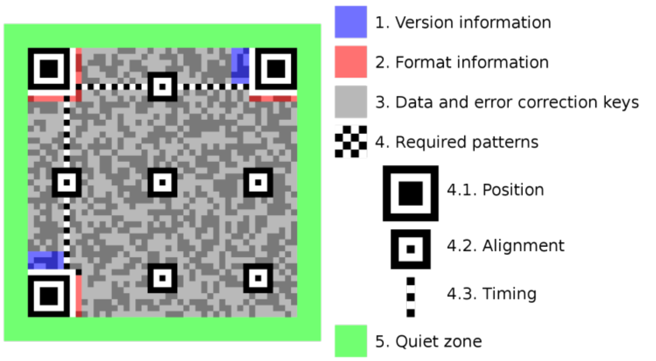

Fig. 1 Structure of the QR code.

The Fig. 1 shows the basic structure of a QR code. The lowest version of the code is version 1, which has 21 x 21 matrices, while the largest prevailing version is version 40, which has 177 × 177 matrices. The percentage of the error correction level and mask pattern are stored in this matrix by formatting the information. When the QR code is decoded, this pattern will be read first. Next to the separators section, the illustrated design above is consisting of 15 bits for formatting. For the purpose to be used as errors and data correction keys, the particular data is transformed to bits and stored in an 8-bit format. Each design as shown in Fig. 1 is a three-by-three matrix where black, white, and black again surround this matrix. The design joins three-position motifs together, which keep track of the density and definition of different QR Code variants. To recognize the finder pattern, a QR code requires a quiet zone that is equal to four module thickness and is bordered by white. The purpose of this pattern is to increase code recognition by decoder software when used in timing patterns. Except for version 1, all codes have the same pattern as the alignment.

In this study we focus on data capacity enhancement of the QR code by proposing a novel simple, user friendly encoding and decoding algorithm for a multi layered data storage pattern. The proposed algorithm will be discussed in detail by providing adequate information for a basic implementation of 8-layered QR code with lower data processing complexity.

II. METHODOLOGY

I. Encoding

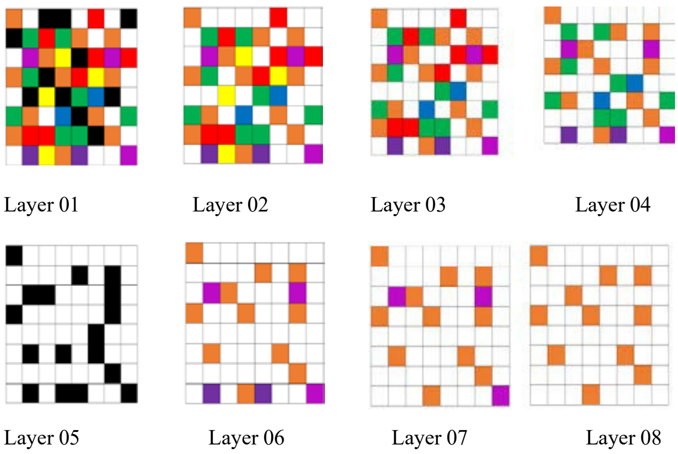

Fig. 2 Black and White QR codes that needs to be combined.

As mentioned in section I, the basic black and white QR codes are assigned with the numbers 1 and 0 respectively for data representation. In here, we propose to add 8 separate QR black and white codes which are represented as 8 layers, where with summation of each cell the maximum number of the data cell will be represented 8 and the minimum number will be represented as 0. With such combination, it is difficult to decode back the multi layered version of the code to original QR code representations named as layer 1,2, 3, up to level 8 (Fig. 2). Therefore, as the next step of the encoding process we propose to multiply each layer of QR code with "$2^n - 1$", where 'n' represents the number of the layers in each code. Thus, instead of 1/0's these new QR codes are consisting of 1/0, 3/0, 7/0 which can be represented up to $(2^n - 1)$/0's. By combining each level sequentially, we obtain 2^n amount of unique combinations where each number can be assigned with a unique color to represent each data cell. The final output QR code will be constructed by assigning colors according to the number of layers that used to construct the output QR code.

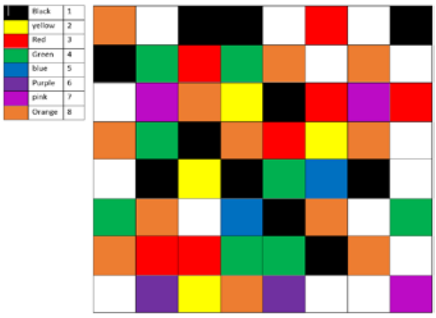

Fig. 3 Output QR code after combining all 8 layers of Black and White QR codes

For an example consider a scenario where number of layers that needs to be combined as 4. (layer 1+layer 2+layer 3+layer 4). Therefore, number of maximum unique numbers we can get from adding these 4 layers is 16. Instead of assigning one particular color to one combination, in here we assign color range to each unique combination. As we are required to print a color in practical implementation, we use exact middle hex code in particular color range as the color. Moreover, as an extra data we wish to include the number of layers which we have used to be printed in the QR code.

II. Decoding

As our input code in the decoding process, we obtain a QR code with multiple colors. When we scan it, first we need to identify the number of layers which were used to construct the composite code with the assigned color for each unique number. Next, we can identify the color ranges used in this particular QR code and begin the decoding process.
As an example, let us consider 2x2 multi-layered QR code with 4 layers as shown in Fig.4.

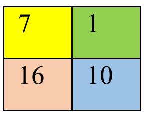

Fig. 4 2x2 Multi-Layered QR code

The unique way to construct these numbers with proposed algorithm are as follows.

Yellow = 7 7 (Layer 3)
green = 1 1 (Layer 1)
pink = 16 1 (Layer 1) + 15 (Layer 4)
blue = 10 3 (Layer 2) + 7 (Layer 3)

Thus, the decoded original layers of QR codes are as follows,

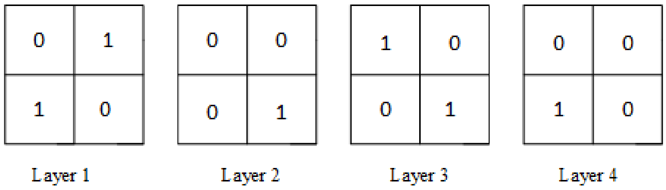

Fig. 5 decoded layers of multi-layered QR code

III. RESULTS AND DISCUSSION

As the proposed multi-layered QR code is scanned from a camera, depending on the device and its` accuracy, hex color code which the camera could identify can be varied. Therefore, to minimize the error we propose to use a middle hex code of our color range, where camera can identify any color within that particular color range. Table 1 illustrates from which factor these color values can be varied. All the values in the table are decimal values, according to the Hex color range values. Hex color range varies from #000000-#FFFFFF while its respective decimal range varies from 000000-16777215.

Table 1: Margin for error with respect to number of layers use in the input.

Number of layers	2	3	4	5	n
Color can be varies from this factor (decimal)	±4,194,30	±2,097,151.875	±1,048,575.937	…	$\pm\frac{16777215}{2^n}$
Color can be varies from this factor (Hex)	#3FFFFF	#1FFFFF	#FFFFF	…	
Number of Colors	4	8	16	…	2^n

From aforementioned data in table 1, it is observed that when the number of layers are increased, the margin for error is decreased accordingly.

IV. CONCLUSION

QR code is one of the prominent ways to convey valuable data and information along with user authentication for modern security systems. In this study a novel algorithm is proposed to enhance the data capacity of QR codes by adopting multiple layers within a single code representation. The proposed algorithm enhances the data capacity one to one with the increased number of layers and it is shown that with the increment of layers the marginal error is also decreased, thus increasing the accuracy of the proposed algorithm. A version 40 QR code with 15 layers can hold up to 45kb of data with a marginal error of ±512. The design can be easily implemented and in compared to the prevailing QR codes, by using this encoding and decoding process the user capacity for a single QR can also be easily increased by reducing the latency of processing for multiple QR codes assigned to each user.

References

[1] J.H.Chang. An introduction to using QR codes in scholarly journals. Sci Ed, Vol.1, Pp.113-1172014.

[2] P.N.A.A. Binti,A.B. SABRI and B.I.N.Roshidi, Enhancing Data Storage Of Coloured QR Code Using C3M Technique. European Journal of Molecular & Clinical Medicine, Vol.7, Pp.2020.