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Enhancing Data Storage Of Colored QR Code Using C3M Technique

Puteri Nurul'Ain Adil BINTI MD SABRI[1], Azizi BIN ABAS[2], Roshidi BIN DIN[3]

[1,2,3]*School of Computing, UUM College Arts and Sciences, Universiti Utara Malaysia,06010, Sintok, Kedah, Malaysia*

e-mail: azizia@uum.edu.my[2]

Abstract: The QR (Quick Response) Code became popular nowadays between us such as on flyers, posters, magazines, and so on. The QR Code can be printed in a smaller space that can store more information, more character types, also allowing users to interact with the world using their smartphone. Due to this pandemic era, users have to scan the QR Code once to enter some places to allows the owner to keep track of each customer that enters their premises. Therefore, the main objective of this article is to enhanced data storage of colored QR Code using the C3M technique to ensure that every data can be store safely on the server. This article will briefly explain how to use compression, multiplexing, multilayer, and multicolor techniques. The multicolor technique will use a combination of eight colored QR Code, which is known as Black, White, Red, Green, Blue, Cyan, Magenta, and Yellow (BWRGBCMY) and as a result, the storage capacity will be increased three times more than the original QR Code

Keywords: Compression; Multilayer; Multicolor; Multiplexing; Qr Code.

1. INTRODUCTION

A QR Code is a 2D barcode (two-dimensional) that can be grouped in a matrix barcode that can store data information based on their allocation capacity. The QR Code is familiar in usage to track the parcel, item tagging, contact information, and ticketing. The QR Code also acts as a creator that allows its information to decoded at high speed [1]. QR Code in Figure 1 holds information in the dual-direction which is vertical and horizontal [2] that contains up to a hundred times more information than a one-dimensional barcode in Figure 2. QR Code is introduced by Denso Wave, Japan in 1994 that has been approved as in AIM Standard, a JIS Standard, and ISO Standard. After that, in the year 2000, the QR Code is being approved to be issued by National Standard in China. The main feature of the QR Code is its data capacity and capability to directly encode Japanese Kanji and Kana characters[3].

Figure 1: QR Code

Figure 2: Barcode

A QR Code is represented by two colors which are black and white in square shape. The black square in QR Code holds value 1 and the white square hold value 0 [4]. To get maximum capacity for each character, both colors black and white in the QR Code are also allowed to encode and decode the process. For example, Numeric character contains number only 0-9, Alphanumeric character can hold a number (0-9), letter either capital letter or small letter (A-Z, a-z), symbols (@,#,%,*, …) and space, Byte/Binary character (8-bit bytes) and Kanji/Kana (Japanese symbols). Table 1 shows the maximum characters can be stored in the QR Code.

Table 1: The maximum characters can be stored in the QR Code (Quick Response)	
Types of Characters	***Maximum Characters***
Numeric	7089
Alpha-Numeric	4296
Binary	2953
Kanji/Kana	1817

The smallest version is Version 1 that contains 21 x 21 matrixes, followed by Version 2 contains 25 x 25 matrixes and Version 3 contains 29 x 29 matrixes. Each version is increasing matrixes size by four matrixes to the right and four matrixes to the bottom[5]. The latest version of the QR Code is 40 that contains 177 x 177 matrixes. Data information that can store in each version depends on the level of error correction. For example, the latest version can store data information up to 4296 alphanumeric characters.

The capacity of the QR Code depends on various factors such as the type of encoded information (Table 1) and the percentage of the chosen error correction level (Table 2). Information can be recovered even when important parts in the code are misrepresented. The basic characteristics of the QR Code had been summarized as shown in Table 3.

Table 2: Error Correction Level	
L	approximate 7% codewords
M	approximate 15% codewords
Q	approximate 25% codewords
H	approximate 30% codewords

Table 3: The summarization of the basic characteristics of the QR Code	
Types of characters	• Numeric • Alphanumeric • Binary • Kanji/Kana
Color Matrix	• Black • White
Version	• Version 1 – Version 40
Error Correction Level	• Lower (L)

	• Medium (M) • Quartile (Q) • High (H)

Problem Statement

Before a two-dimension barcode was introduced, a one-dimension barcode has been used. In a one-dimension barcode, just horizontal store data information. The maximum data storage capacity for a one-dimension barcode is only up to 20 characters. So, it cannot store more data information just in a row, it needs more row to store more data information. Just because of that, a two-dimension barcode (QR Code) introduces and improvises from time to time to ensure that can fulfill current needs. As mentioned in the introduction, the QR Code itself has many uses in a variety of applications. Nowadays in the pandemic era, each customer needs to scan a QR Code before they can enter premises. After that, as output, some customer's data information such as name as registered, phone number, premises details like name, day, and time will display and recorded into a server. It is easy to keep track of related customer if something worse happened at that premise. It very assists to retrieve all customer's information to do a survey. Due to that situation, data storage of the QR Code should be enhanced. The originality maximum data storage capability of the QR Code by using only two colors which is black and white for version 40 is 4296 characters. This data storage capacity can be enhanced by adding more colors along with black and white colors such as red, blue, green, cyan, magenta, and yellow [6]. To increase data storage capacity more times than usual, various techniques have been suggested and a few techniques have been selected, for example, compression [7], multiplexing [8], multilayer[9]. Besides, multicolor layering is added in the multilayer technique to overcome the size limitation for a black and white QR code [7]. All four techniques are explained well in Section 3.

Literature Review

QR Code contains a different area that has a specific purpose[10]. Figure 3 shows the basic structure that all QR Code contains. Besides that, in this section, a few techniques that are related to how to enhance data storage of the QR Code will be briefly discussed. The techniques are compression, multiplexing, multilayer, and multicolor. That technique has its way of enhancing the data storage and different each other technique.

A. QR Code Structure

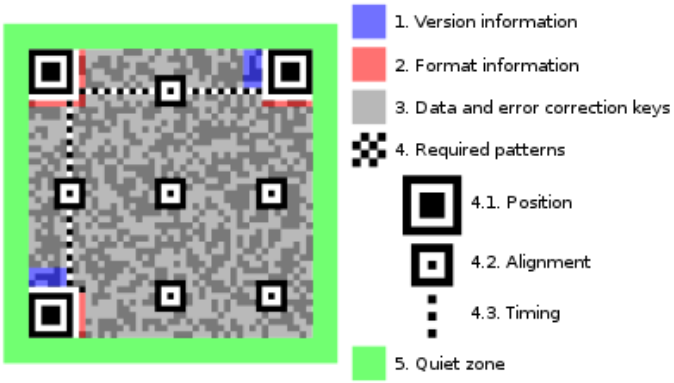

Figure 3: The structure of the QR Code

Version Information:

Version information pattern is a 6 x 3 size blue colored place beside the finder pattern as shown in Figure 3 above. It starts with version 1 as the smallest version that consists of 21 x 21

matrixes and ends up with version 40 as the largest version that consists of 177 x 177 matrixes. The total version of the QR Code is 40.

Format Information:
This pattern stores information about the percentage of the error correction level and mask pattern. This pattern will read first when the QR Code is decoded. This pattern also consists of 15bits next to the separators section.

Data and Error Correction keys:
Information converted into the bit and stored in 8bits.
Required patterns:

- Position: This pattern is placed in three corners except in the right bottom corner. Each pattern size 3 x 3 matrix. This matrix is surrounded by black, white, and black again.
- Alignment: All version has this pattern exclude Version 1.
- Timing: This pattern is a connection between three-position patterns. They hold the density and definition of QR Code's versions.

Quiet Zone:
A QR Code needs a quiet zone to identify the Finder pattern that consists of equal to four module thickness with white-colored surrounded by QR Code. The function of this pattern is to improve code recognition that using in Timing Patterns by the decoder software.

B. Compression

Compression is a technique that reducing information size by removing unnecessary items and double spaces. Transmission of large files can cause congestion in networks and take a long time due to lag in bandwidth [11]. Then, compression is useful in certain situations where is needed to send a large file through the network. In another word, compression means to remove the redundancy information that store in storage, take less time to transfer data between device due to the file size is smaller than the original. The compression technique uses two-step converting information into binary data and generates compressed information from binary data [12]. A basic illustration of the compression technique is shown in Figure 4. The process begins with data information or can be assigned as an original message. Then to save the space in QR Code, a compression technique will be used to compress the information as much as can. The final product will be called compressed information.

Figure 4: A compression technique of an Information

Type of Compression:

- Lossy compression

Compressed information is not the same as the original information before using the compression technique. A lossy compress was suitable to use in the image. It is also used in audio and video to compress when to store them into QR Code[13].

- Lossless compression

Information not lost after decompression while using this one. It can save bandwidth [14] and storage space [15]. It is lossless means that any kind of information that compresses is exact as original information. Zip and GZip tools also use this type of compression, lossless compression.

Table 4: The comparison Lossy and Lossless Compression Technique		
Feature	***Lossy Compression***	***Lossless Compression***
Storage Capacity	Less	More
Loss of Information	Yes	No

Table 4 shows the comparison between two types of compression which is a lossy compression and lossless compression. The lossy compression is suitable for an image, audio, video meanwhile lossless compression suitable for data information, especially in a text. Then, after reviewing different techniques for both types of data compression, the ZIP compression technique is the best because it is lossless compression. Related work from the previous compression technique is summarized in Table 5.

Table 5: The summarization of the compression technique of colored QR Code			
No.	***Researcher & Year***	***Advantage***	***Error Correction***
1	N. Victor (2012)[12]	Can store up more than 4kb data storage in QR Code	Reed Solomon
2	Mona M. Umaria; G.B. Jethava (2015)[16]	Able to increase data store 3 times than usual	Reed Solomon

C. Multiplexing

Generally, multiplexing is an approach of combining or merging multiple streams into a single medium [17]. In QR Code, multiplexing is a combination of two or more QR Code into a single QR Code. This multiplexing technique also can be used to enhance data storage capacity in the QR Code. At first, referring to the level of error correction and the maximum character storage availability, eight black, and eight white QR Code have been generated [18]. Figure 5 shows how the multiplexing process occurs from more than one QR Code combine and becomes a single QR Code and then the demultiplexing process occurs from a single QR Code to the original eight QR Code.

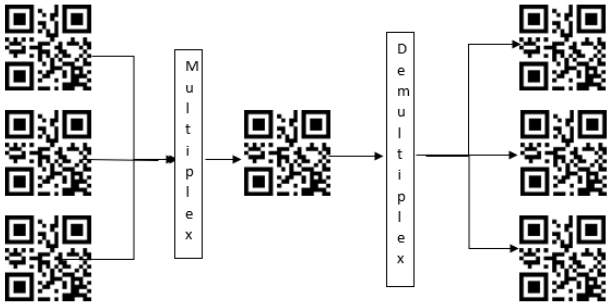

Figure 5: The process of multiplexing technique

Next in the multiplexing technique, the sentence “I LOVE PROGRAMMING” acts original information use as an example. The information was divided into three parts known as “I”, “LOVE”, “PROGRAMMING”. Information in each part was converted into three QR Code. At the receiving part, this QR Code has scanned by the system and demultiplexed these three QR Code into a single QR Code. At last, all information is linked to each other and back as original information, “I LOVE PROGRAMMING”[19].

Table 6: The summarization of the multiplexing technique of colored QR Code			
No.	***Researcher & Year***	***Advantage***	***Error Correction***
1	Sartid Vongpradhip (2013)[19]	Able to increase data store 3 times than usual	Reed Solomon
2	Hiren J. Galiyawala and Kinjal H. Pandya (2014)[20]	Able to increase data store 24 times than usual	Reed Solomon

D. Multilayer

The multilayer technique will proceed with the flow by combining red, green, blue QR Code into colored QR Code after the multiplexing technique is completely generated. Figure 6 shows that QR1, QR2, and QR3 is multiplexed single QR Code converted into multi-colored QR Code using Kaywa QR Code Generator. The last product in the right column is colored QR Code after combined QR1: Red, QR2: Green, and QR3: Blue. As a result, the layered QR Code can store multiple data storage contrasts to the original black and white QR Code [21].

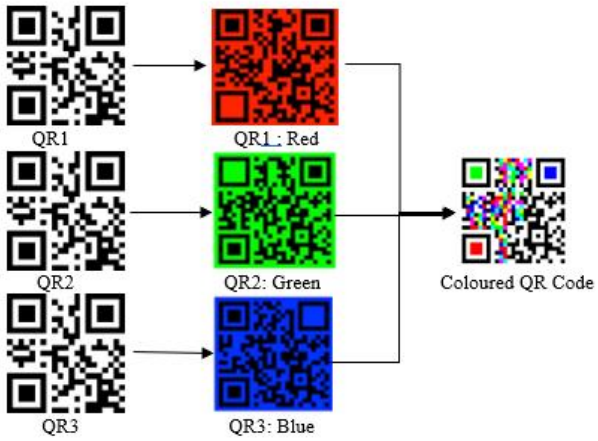

Figure 6: Multilayer process after Multiplexing technique completed

Meanwhile, the increments data storage capacity and color used in the QR Code for the multilayer technique based on the previous researcher is summarized as in Table 7.

Table 7: The summarization of the multilayer technique of colored QR Code			
No.	***Researcher & Year***	***Advantage***	***Colors***
1	A. Abas, Y. Yusof, and F. Kabir (2016) [17]	Able to increase data capacity 3 times than usual based on layer combination	Red Green Blue
2	M. Ramya and M. Jayasheela (2014) [22]	Able to increase data capacity 3 times than usual based on layer combination	Cyan Magenta Yellow

E. Multicolor

The multicolor technique was added after the multilayer technique just to overcome the limitations of data storage in a black and white QR Code[9].The multicolor technique is like the multilayer technique but in multicolor technique, [23] manipulated color from three basic color, Red [255,0,0], Green [0,255,0], Blue[0,0,255] to another three color known as Cyan [0,255,255],Magenta [255,0,255], and Yellow [255,255,0][24]. These eight colors are illustrated in the diagram as shown in Figure 7.

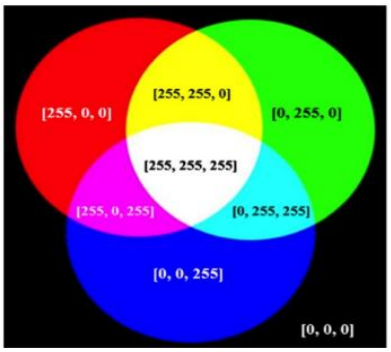

Figure 7: Eight possible color combinations and their intensities

After these eight colors combined and become a single multicolored QR Code, the storage capacity also increased as much. Therefore, color combination cannot be simply chosen either the orthogonality of the base colors in color space will lose. Then, to overcome this issue and maintain orthogonality, [23] choose different intensity levels from three basic colors red, green, blue which is high and low intensity. Current implementation using a high intensity of 170 and low intensity of 85 changed to 255 as maximum and 0 as minimum intensity values. As a result, with three combination colors, another three possible colors were detected.

Table 8: The summarization of the multicolor technique of colored QR Code

No.	***Researcher & Year***	***Advantage***	***Error Correction***
1	P. N.Pillai And K. Naresh (2014) [25]	Able to increase data capacity 3 times than usual	Reed Solomon
2	B. Yusuf *et al.* (2015)[26]	QR Code is readable in both direction vertical and horizontal with 360 degree	Reed Solomon

2. CONCLUSION

This article shows that data storage capacity can be enhanced by using these four types of technology known as compression, multiplexing, multilayer, and multicolor technique. Even though just by using a compression technique, data storage also can be enhanced, combined with these three another technique also can make data storage capacity enhanced more times than usual. The color QR code data size is equal to the number of layered colors consists of QR code. At the end of this research, the storage of the QR Code will be enhanced, and because of that its capability to store data information without requiring a larger QR Code to be used also increases [21]. However, to get more data storage than this, and data information also can be secured, the encoding and decoding algorithm for each technique also can be improved.

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REFERENCES

[1] P Sutheebanjard and W Premchaiswadi. QR-code generator. *In*: 2010 Eighth International Conference on ICT and Knowledge Engineering, Bangkok. 2010, p. 89-92.

[2] MA Bin Ramlan and NIB Alias, Multi Conference Registration System (MRMS) Using Barcode Identification. *Int. J. Adv. Trends Comput. Sci. Eng*. 2019; **8**, 13-17.
[3] H Kato and KT Tan. 2D Barcodes For Mobile Phones. *In*: IET Conf. Publ., 2005, p. 48-48.
[4] T Nikolaos and T Kiyoshi. QR-code calibration for mobile augmented reality applications: linking a unique physical location to the digital world. 2010, p. 1.
[5] A Abas, Y Yusof, R Din, F Azali and B Osman. Increasing Data Storage Of Coloured QR Code Using Compress, Multiplexing And Multilayered Technique. *Bull. Electr. Eng. Informatics*. 2020; **9**, 2555-2561.
[6] PN Pillai and K Naresh. Improving The Capacity Of QR Code By Using Color Technique. *Int. J. Adv. Res. Electr. Electron. Instrum. Eng*. 2014; **3**, 10561-10567.
[7] K Tan, D Chai, H Kato and S Ong. Designing A Color Barcode For Mobile Applications. *IEEE Pervasive Comput*. 2012; **11**, 50-55.
[8] PS André and RAS Ferreira. Colour Multiplexing Of Quick-Response (QR) Codes. *Electron. Lett*. 2014; **50**, 1828-1830.
[9] B Badawi, TNM Aris, N Mustapha and N Manshor. A Fuzzy Multi-Layer Color Qr Code Decoder Algorithm. *Int. J. Adv. Trends Comput. Sci. Eng*. 2019; **8**, 131-137.
[10] P Kieseberg, M Leithner, M Mulazzani, L Munroe, S Schrittwieser, M Sinha and E Weippl. QR code security. *In*: Proceedings of the 8th International Conference on Advances in Mobile Computing and Multimedia (MoMM '10), New York, NY. 2010, p. 430-435.
[11] SR Prakash and V Shetty. Review On Optimization Techniques Used For Image Compression. *Int. J. Res. Eng. Technol*. 2015; **4**, 562-567.
[12] N Victor. Enhancing The Data Capacity Of QR Codes By Compressing The Data Before Generation. *Int. J. Comput. Appl*. 2012; **60**, 17-21.
[13] JH Pujar and LM Kadlaskar. A New Lossless Method Of Image Compression And Decompression Using Huffman Coding Techniques. *J. Theor. Appl. Inf. Technol*. 2010; **15**, 18-23.
[14] K Kumar, P Sharma and AK Singh. Configuring The System To Share Internet From Single User To Multi-User With Single Internet Dongle. *Int. J. Soft Comput. Eng*. 2012; **4**, 32–35.
[15] Azita Mayeli and Mohammad Razani. *Multiplexing And Demultiplexing Frame Pairs*. *In*: A Mayeli, A Iosevich, PET Jorgensen, G Ólafsson (Ed.). Commutative and Noncommutative Harmonic Analysis and Applications. 2013.
[16] MM Umaria and GB Jethava. Enhancing The Data Storage Capacity In QR Code Using Compression Algorithm And Achieving Security And Further Data Storage Capacity Improvement Using Multiplexing. *In*: Proc. - 2015 Int. Conf. Comput. Intell. Commun. Networks, CICN 2015, 2016, p. 1094-1096.
[17] A Abas, Y Yusof and F Kabir. Improving Data Capacity Of QR Code Version 40 Using Multiplexing And Multilayered Techniques: Embedding Text Based Short Story In QR Code. *Adv. Sci. Lett*. 2016; **22**, 2841-2846.
[18] A Singh. Increasing Storage Capacity Of Qr Codes. 2017.
[19] S Vongpradhip. Use Multiplexing To Increase Information In QR Code. *In*: Proc. 8th Int. Conf. Comput. Sci. Educ. ICCSE 2013, 2013, p. 361-364.
[20] HJ Galiyawala and KH Pandya. To Increase Data Capacity Of QR Code Using Multiplexing With Color Coding: An Example Of Embedding Speech Signal In QR Code. *In*: 11th IEEE India Conf. Emerg. Trends Innov. Technol. INDICON 2014, 2015, p. 2-7.
[21] C Nesson. Encoding Multi-Layered Data Into QR Codes For Increased Capacity And Security. 2013.

[22] M Ramya and M Jayasheela. Improved Color QR Codes For Real Time Applications With High Embedding Capacity. *Int. J. Comput. App*l. 2014; **91**, 8-12.
[23] JM Meruga et al. Multi-Layered Covert QR Codes For Increased Capacity And Security. *Int. J. Comput. Appl*. 2015; **37**, 17-27.
[24] DRVA Sharath Kumar and PA Lovina. Hardware Obfuscation Driven By QR Pattern Using High Level Transformations. *Int. J. Adv. Trends Comput. Sci. Eng*. 2019; **8**, 38-41.
[25] PN Pillai and K Naresh. Improving The Capacity Of QR Code By Using Color Technique. *Int. J. Adv. Res. Electr. Electron. Instrum. Eng*. 2014; **3**, 10561-10567.
[26] B. Yusuf *et al*. Multicolor and multiple QR Code based information support system during disaster for elderly people. *In*: 2015 International Conference on Informatics, Electronics & Vision (ICIEV), Fukuoka. 2015, p. 1-6.