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A Review on QR Codes: Colored and Image Embedded

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Abstract: QR Code (Abbreviation of Quick Response Code) is a 2-Dimensional Barcode which is presently trending in today's technological world. It is such created to be scanned and read by smart phones embedded with camera and decoding application. QR Codes act as an ample tool to swiftly and affluently convert URL for users. The capacity data repository of QR Codes is higher than Barcodes and can be further enhanced to next level with the use of colors which act as a third factor.
This paper is an attempt to present researches done on QR Codes and different ways used to improve its performance and appearance.

Keywords: QR Code, Barcode, types, Versions, embedding, error-correction, HCCB, HCC2D, Color QR Code.

INTRODUCTION

QR Codes were introduced by Denso Wave Toyota Motors subsidiary (Japan) in year 1994 [1]. These codes may capture information like URL links, contact details, business cards, automated SMS messages, geographical locations, newspapers, magazines or any other offline media which is possible to be embedded into 2-D barcodes. QR codes have capacity to store big amount of data, i.e., 7,089 bits of numeric data and 4,296 bits of alphanumeric data which makes it more useable than contrary barcodes.

(a) Process of Encoding:-
QR code is made up of small square boxes of random series of black and white pixels [1]. Data in QR codes is stored in binarised format and Black Square represents 1bit whereas White Square represent 0 bit. QR code also includes finder patterns, alignment patterns and timing patterns that make it more easily detectable and also decodable [2]. The data being captured into binary format is given color or black-white format this is then placed into cress-cross arrangement.

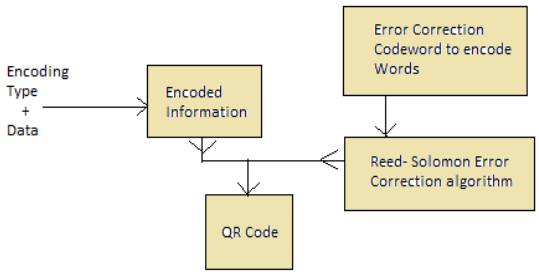

Fig1: Encoding process of QR Code

(b) Architecture:-
The architecture of QR code [3] contains many parts, namely, alignment patterns, timing patterns, separators, format information etc. due to which QR codes are efficient and easy to use. Given below is briefing of these parts:-
(I) Alignment Pattern: - It helps to correct attenuations that generates while capturing the code.
(II) Data: - The portion of QR code where message/data is encoded is in this part. After encoding Reed-Solomon codes are used for error correction.
(III) Format Information: - It contains information about selected mask pattern and error correction levels making use of 15 bits. It is helpful during decoding.
(IV) Position Patterns: - These are 3 small squares present at 3 corners of QR code and help to detect position of QR code on media.
(V) Quite Zone: - This is 4 bits margin around the QR code to separate it from surrounding excess text or printed things.
(VI) Separators: - These are separating white pixels used for distinguishing data from different elements of QR code.
(VII) Timing Pattern: - These are placed between alternative position patterns and find the central coordinate of every cell.
(VIII) Version: - It tells about version of QR code being used out of 40 different available versions.

(c) Versions [4] [5]:-
The versions of QR code ranges from version 1 to version 40 [4] and each version is differentiated by its "Module Configuration" [5]. With each consecutive version number of modules is increased by 4 as given in below diagram Fig3. , which shows images for a few versions of QR codes.

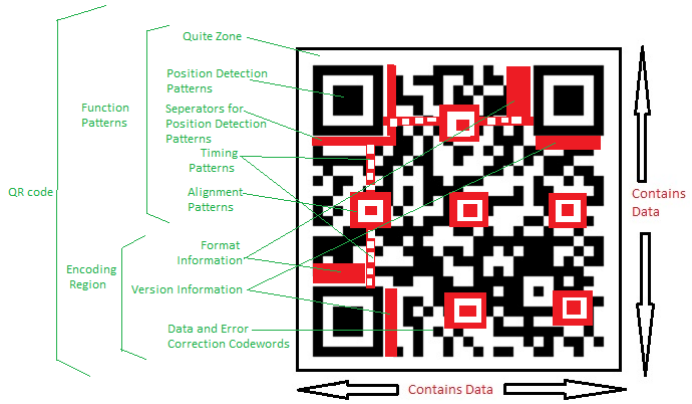

Fig2: Architecture of QR Code

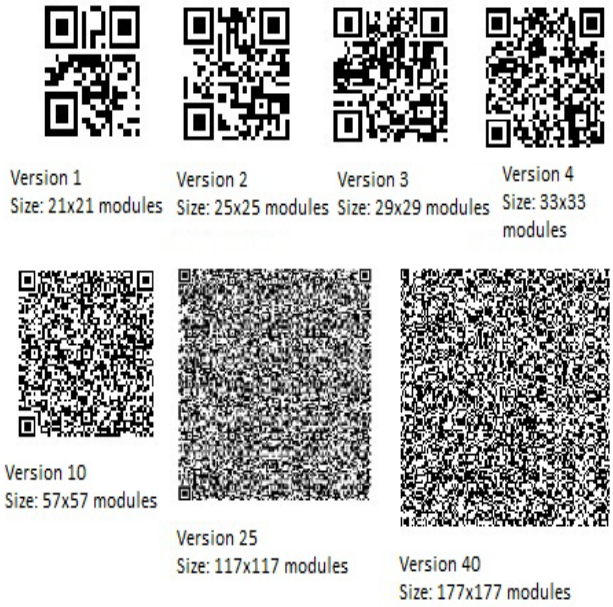

Fig3: Versions of QR Code Symbol

Every QR code symbol version contains maximum data capacity in accordance to the error correction level, character type and amount of data stored. As amount of data increases excess modules are needed to make QR code which results in bigger QR code.

(d) Error Correction:-
Error correction [4] [5] techniques are used to extract data from damaged QR code. Each word of QR code is 8 bits long. QR Codes uses Reed-Solomon error correction algorithm for correcting errors and damaged parts.

Fig4: QR Codes with errors

Reed-Solomon Code is a specific type of BCH Code (Bose-Chaudhuri-Hocquenghem Code, a cyclic error-correction code) [6]. Error correction is taken into account while encoding and is helpful to recover damaged QR code while decoding it. Reed-Solomon algorithm has four increasing error correction levels namely L, M, Q and H. If we use higher correction level then storage capacity of code will decrease accordingly and vice-versa.

Table1 [6]: Error Correction levels

Level L (Low)	7%
Level M (Medium)	15%
Level Q (Quartile)	25%
Level H (High)	30%

Above table shows the percentage of codeword that can be restored in each level of error correction. In case, if the QR code is too large than it will be divided into many smaller Reed-Solomon code blocks. Maximum error correction that could be made in each block is 15 errors.

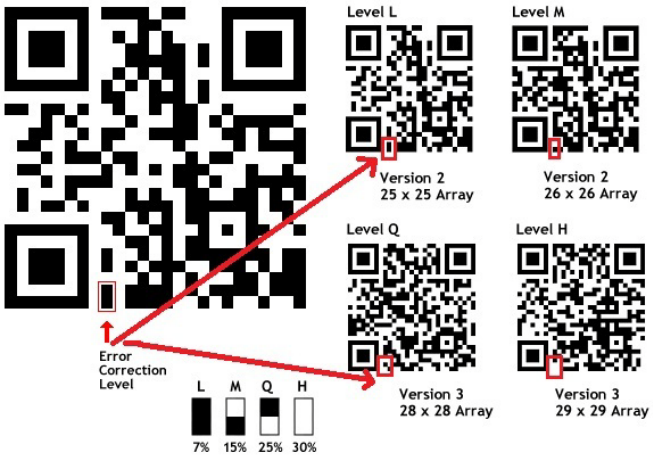

Fig5: Embedding Error –correction in QR Codes

This technique sometimes uses colors, logos etc. in recovering damaged QR codes to make them look more appealing and easily readable.

Fig6: Recovered QR Codes

(e) Advantages and disadvantages:-
QR Codes have many features that make it so popular such as increased and large data capacity, 360 degree flexible reading, durability against damage and dirt issues, high speed of decoding, optimum and reduced size, all language support.

It has some disadvantages also such as user need to download a QR Code reader, lack of awareness, scanning can be a long process and there are some other popular options available.

(f) Applications:-
Now days we see QR codes everywhere around us just like Barcodes. The markets of traditional barcodes are being slowly overtaken by QR codes and they are getting more and more popular with every passing day. QR codes are seen on products to provide information about the manufacturing company and product, advertisement of assets, for tracking of products, for providing information about coming event or conference, on jewelry, as a part of interactive maps, on posters, books or other study materials etc.
QR Codes are also used in many applications like WeChat, WhatsApp and Super Beam etc. for identification and Paytm for making online payments.
QR Codes are even found on AADHAR CARDS which is issued by UIDAI (Unique Identification Authority of India) that contains all the information about the cardholder in electronic form.

COLORED QR CODES

Now days we see "Colorful Custom QR codes" [7] and they are misunderstood with colored QR codes. The capacity of customized QR code is same as that of traditional black and white QR codes because they too are made up of two colors, one of high contrast and other of low contrast. Due to this they are also decoded using 2 color buckets just like black and white QR code.

Fig7: Colorful Customized QR Codes

Figure 7 show beautified 2 dimensional QR codes which are encoded and decoded the same way as black and white QR code also have same data capacity and error correction implementations.
By adding more than 2 colors to QR code the capacity of storing data will be increased to a greater extent. "Colored QR Codes" are under research and still a proposal to be implemented in reality [7].

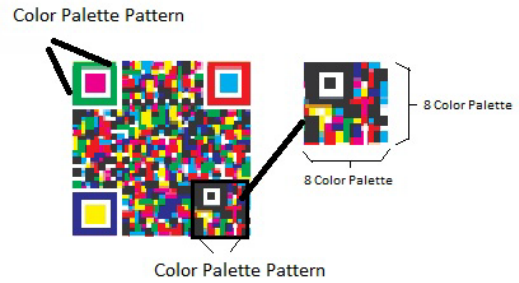

Fig8: Multi colored QR Code

Colored QR codes are named as HCC2D (QR codes + multiple colors). Densities of some of the famous encoding techniques are tabled below:-

Table2: Data Densities of encoding techniques

Technique Type	Data Density (bits per sq. inch)
QR code	5,016
HCC2D (High Capacity Color 2 Dimensional) QR code	15,048
HCCB (High Capacity Color Barcode)	16,000

By addition of third factor, i.e., colors to QR codes more information can be stored in same area compared to the black and white QR code. Multiple colors act as a medium to hold information and make the QR codes work as 3-Dimensional rather than two colored QR codes which are 2-Dimensional. Presently colored QR codes are not in use anywhere because they have many complicated issues related to them due to which they are under research.
HCCB (High Capacity Color Barcode) is an encoding technique which is also under research just like colored QR codes and has scope in future encoding markets. It is being developed by Microsoft for capturing encoded data in 2D barcodes. In HCCB colored triangles are used instead of square pixels in QR codes and line pattern in traditional barcodes [8]. Figure 9 given below show different techniques that are presently used in markets for encoding data and also future replacements of these techniques.

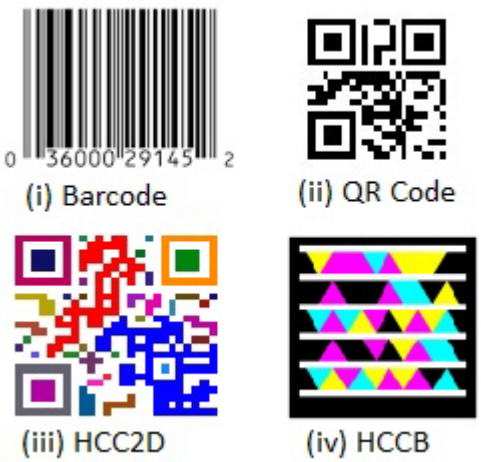

Fig9: Present and future encoding techniques

EMBEDDING QR CODES IN IMAGES

QR Codes come with some pitfalls and one of them is that it is square in shape; also tolerance of color is incomplete [9]. Solution to these problems is sought by embedding QR code into colored images as background. Due to this embedding, the pixels of image get laminated. But an optimum technique must be used for embedding so that the corrupted modules would be available for use.

Halftoning method and error diffusion [9] is one such technique. This technique follows a process of dividing every module of QR code in 3*3 pixel sizes and then dominant pixels are set to value of QR code.

After this, left over pixels help to minimize probability of error by creating a halftone of the image [9]. After Halftoning the data is in binary format and error diffusion method is used to embed QR code into color image.

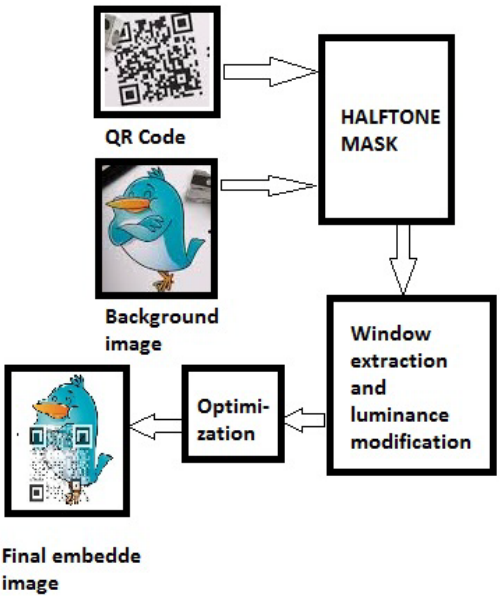

Fig10: Embedding QR code in images

CONCLUSION AND FUTURE WORK

Most of the recent and edged developments in QR codes is reviewed and concluded in this paper. QR Codes have a large scope in present and future aspects of encoding data. Hence they can be optimized to further extent in different manners such as improving data capacity, reducing size, improving visual appearance, reducing processing time, increasing security towards phishing attacks, improving recovery process etc.

Also the uses of QR codes in different fields are yet to be explored. The future of QR code would be encoding them in multiple colors and encoding of different kind of data like audio within QR codes.

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