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ENRICHMENT OF STORAGE CAPACITY OF QR CODES USING COLORED APPROACH

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Abstract
Copyright protection and authentication is increasing and becoming important in daily life. The digitized watermark is one of the techniques invented to solve this issue. Max storage capacity of QR code with the use of only two colors i:e Black and White is Maximum upto 4296 characters in version 40. This capacity of QR can be further enhanced by the utilization of more colors with black and white which can be red, green, blue etc. or by the utilization of multiplexing technique In this research paper, a new color QR code generation algorithm is proposed, which uses all the two multiplexing technique and color coding technique. This enhanced algorithm increases the capacity of QR code by 3 times as compared to the present black and white QR codes. QR code which is damaged up to 30% can be efficiently decoded or scanned using RS codes. The codeword of RS are generated through a set of finite fields.

Key Words: QR Code, 1D Bar Codes, 2D Matrix Codes, RS Codes, Finite Fields, Color Coding.
Key Words: 2D Barcodes, Data Capacity, Data Compression, Lossless Compression, QR Code.

1. Introduction

Bar codes have become widely popular because of its reading speed, accuracy, and superior functionality characteristics. Barcodes can be divided as 1D and 2D. 1D barcodes can express information in horizontal direction only. And, the data Storage capacity is limited. 2D barcodes can hold data both in horizontal and vertical direction. As a result, the data capacity is 100 times more than the 1D barcode [1].

As bar codes became popular and their convenience universally recognized, the market began to call for codes capable of storing more information, more character types, and that could be printed in a smaller space. However, these improvements also caused problems such as enlarging the bar code area, complicating reading operations, and increasing printing cost. 2D Code emerged in response to these needs and problems [2].

QR Code is a kind of 2-D (two-dimensional) symbology developed by Denso Automotives Wave and released in 1994 with the primary aim of being a symbol that is interpreted by scanning equipment [3]. 2D bar codes can act like identifier (like in 1D) but takes less space. Alternatively, it can function as a database itself.

QR Code holds a considerably greater volume of information than a bar code. These can be numeric, alphanumeric or binary data – of which up to 2953 bytes can be stored. Only a part of each QR bar code contains actual data, including error correction information. A large area of the QR code is used for defining the data format and version as well as for positioning, alignment and timing purposes. The smallest square dot or pixel element of a QR code is called a module. QR Codes have an empty area around the graphic. This quiet area is ideally 4 modules wide. Examination certificates can also use the QR Encoding techniques [4].

This paper proposes a method in which data capacity can be increased by first compressing the data and then encoding it. A lossless compression technique is proposed to increase the data capacity. For decoding the data, two steps will have to be followed. The first step focuses on de-compressing the data using the techniques which are just the reverse of compression technique used here. The second step focuses on decoding the decompressed data. For this, the reverse technique used for encoding the data can be used.

2. Literature Review

Algorithms for encoding and decoding the QR codes are existing in the literature. During the years many have urbanized algorithms for QR codes, a few of them are Sartid Vongpradhip [1] proposed an algorithm to increase the capacity of QR code by using Multiplexing. Md. Wahedul Islam, Saif alZahir [2] proposed a novel QR code guided image stenographic technique. Yinghui Zhang, Tianlei Gao, Deguang Li, Huaqi Lin [3] proposed an algorithm to convert a gray image into binary image. Sartid Vongpradhip, Suppat Rungraungsilp[4] proposed an algorithm , how to use QR Code as Invisible Watermarking. Chun Jin and Jianghong Yuan, Leilei Li, Eryang Chen, Tao Tang[5] and Zhang Yongjun [6]proposed an algorithm to decode the information from the damaged QR coding by using RS error correction code. sartid vongpradhip et al [1] proposed an novel algorithm use multiplexing to increase data storage and information in QR code, in the algorithm three messages are considered and individual QR code are generated, these three QR codes are multiplexed and

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formed into a group of three bits each bit from one QR code and these three bits are assign to a special character. at the final step instead of black or white square this special character is replaced. At the decoder side each special character is read and its related group of three bits is gained and those are again de-multiplexed to the individual QR code.

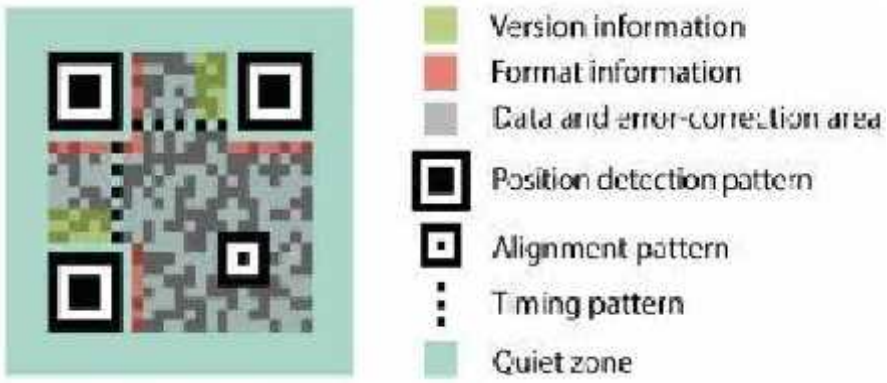


Fig 1: QR Code Structure

3. OBJECTIVE

Reed-Solomon codes are error-correcting codes which are used all over today. Reed-Solomon codes be based on finite fields. Finite fields are also famous as Galois fields in honor of Evariste Galois, who was the first to revise these finite fields.

A field is a set of elements F for which addition, multiplication, subtraction and division performed with its elements upshot in another element of the same set. F is a commutative group with esteem to the addition operation. The identity element for the addition is '0'. It is a commutative group for the multiplication operation. The identity element for multiplication is '1'. Multiplication is distributive with respect to addition a(b + c) = ab + ac. The number of elements in a field is called the order of that field. The inverse for the addition operation of an element of the field a F is denoted as −a,

and inverse for the multiplication operation of an element of the field is denoted as. Subtraction and division operations are defined as a function of the inverse elements as

$$a - b = a + (-b)$$
$$a/b = a(b^{-1})$$

The set = {0, 1} defined under addition and multiplication modulo 2 is such that ={0, 1} is a commutative group with respect to the addition operation, and is also a commutative group with respect to the multiplication operation. This is the so called binary field GF (2). Operations in this binary field are defined by table 1.

+	0	1
0	0	1
1	1	0

table 1.(a) Addition

For the degree of then polynomial m=3 the primitive polynomial is 1+X+ X3 which defines a finite field GF(23). So there are 23 =8 elements in the field defined by f(X). The familiar binary elements 1 and 0 do not satisfy the polynomial f(x) = 1+X+ X3. Let x an element of extension field be defined as a root of the polynomial f(X).

Therefore it is possible to write

$$x^{3} = -x - 1 = x + 1 \text{.....1}$$
$$x^{3} = x(x^{3}) = x^{4} + x \text{.....2}$$
$$x^{5} = x(x^{4}) = x^{3} + x^{4} = x^{4} + x + 1 \text{.....3}$$

$$x^{7} = x(x^{6}) = x^{4} + x^{3} + x = x^{3} + 1 \ldots\ldots\ldots\ldots\ldots\ldots 4$$

$$x^{7} = x(x^{7}) = x^{4} + x = 1 = x^{7} \ldots\ldots\ldots\ldots\ldots\ldots 5$$

Operations performed on finite fields are only addition and multiplication because subtraction is similar to addition and division is equal to multiplication of its inverse.

For example consider GF (23)

The elements are 0, x^{7}, x1, x2, x^{3}, x4, x5, x^{7}.

$x^0+x^5=x^4$
so, in finite fields addition is nothing but xor operation.

$x^2 .x^3=x^5$

4. Methodology

Reed Solomon codes is having extreme (huge) power and helpfulness, and are today found in several applications from dense disc players to external space applications. The Reed-Solomon codes (RS codes) are basically of non binary cyclic codes with code symbols from a Galois field. They were bare in 1960 by I. Reed and G. Solomon. The work was finished when they were at MIT Laboratory. In the decades since their advance, RS codes have enjoyed innumerable applications from compact discs, digital TV in living room to spaceship and satellite in outer space. The most essential RS codes are codes with symbols from GF(2m). One of the most essential features of RS codes is that the minimum distance of an (n, k) RS code is n–k+1. Codes of this breed are called “maximum-distance-separable codes”.

The code is skilled of correcting any combination of t or fewer errors, where t can be expressed as

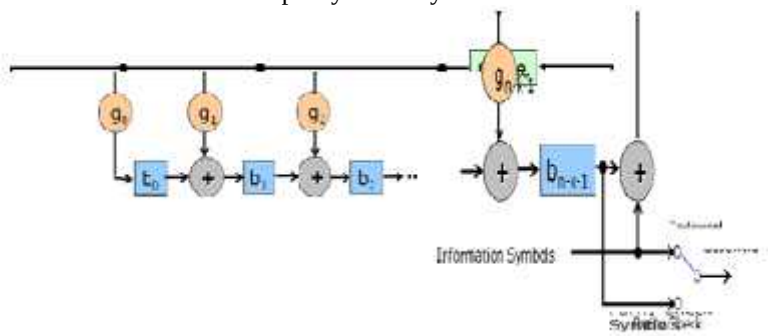
$$t = \frac{Dim - 1}{2}$$

The encoding process can be done in two ways one is division method and second is systematic method.

Division Method

- Multiply the non-binary message
  polynomial m(x) by xn-k
- Dividing xn-km(x) by g(x) to obtain the remainder b(x)

Below Figure shows the encoder circuit diagram. The registers b0, b1, b2……..bn-k-1 are initially filled with zeros. the information symbols are applied as input to the encoder circuit. After the last symbol of information symbols, the values contained in the set of registers will be considered as parity check symbols.



The procedure of the RS decoding algorithm can be decayed into four steps:
Step1: Calculate the syndrome vector.
Step2: Calculate the error location polynomial.
Step3: Calculate the roots of the error location polynomial.
Step4: Calculate the value of the error, and do the error correcting

5. Algorithm

QR Encoding Algorithm

1. Enter the users data to generate the QR code
2. Convert the entered data into its ASCII equivalent
3. Using the ASCII equivalent Finite Fields Numbers are generated by using Primitive polynomial
4. RS Codeword is generated for the pre defined Finite Field number through RS encoder algorithm
5. The codeword is next converted into binary Equivalent code.
6. These binary generated bits are then placed according to the QR code pattern
7. Every users QR code is taken as a color plane
8. With the combination of chosen three color planes, colored QR is generated.

Figure 2: Color QR Encoding Block Diagram

QR Decoding Algorithm

1. The color QR code is Scanned.
2. Saturation of QR onto RGB planes
3. For every plane it eliminate the QR patterns
4. These bits are grouped into 8 bit representation
5. Conversion of the binary to decimal for each byte
6. Apply to RS decoder as input
7. The output of RS decoder is ASCII equivalents
8. Converting them into characters gives the original information

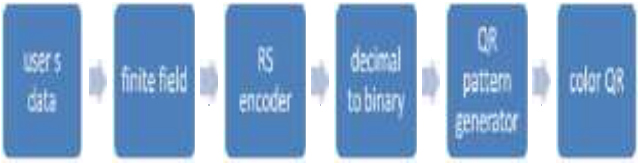


Figure 3: Color QR Decoding Block Diagram

6. Experimental Results

In encoding process, three users information is considered and individual black and white QR code is generated. The black and white QR codes are assign to Red, Green and Blue planes, combining these three planes, color QR code is generated. Similarly, in decoding side colored QR code is split into individual planes (Red, Green and Blue) and decode the information from each plane as shown in below figure.

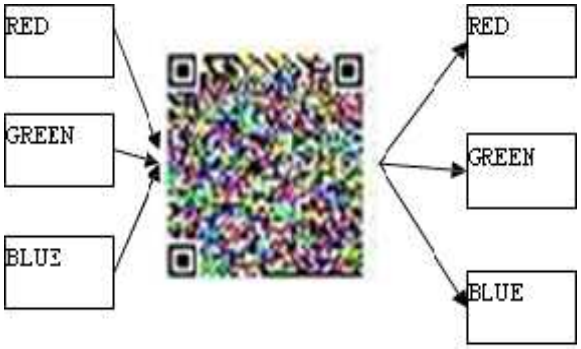


Figure 4: Encoding and Decoding Process of QR Code

The capacity of black and white QR code is up to 233 characters for 48x48 module size. The capacity is increased 3 times of present QR code by considering Red, Green and Blue planes as shown in table 2.

Table2: Capacity of QR Codes

QR Pattern	Information in QR Code	Capacity
	Abstract: Now a days Quick Response (QR) codes are used everywhere, we can see them on posters, magazine ads, websites, product packaging and so on.	Up to 233
	Abstract: Now a days Quick Response (QR) codes are used everywhere, we can see them on posters, magazine ads, websites, product packaging and so on. This capacity can be further increased by considering more colors along with black and white i.e.; red, blue, green etc. or by using multiplexing technique. This algorithm increases the QR code capacity by 3 times compared to the present black and white QR codes. QR code damaged up to 30% can be efficiently decoded using RS codes.	Up to 699 characters (233 * 3)

Using this new technique of compressing the data before generating QR Code, efficiency can be improved. This technique suggests simple ways to accomplish this task. All the text data will be converted into a series of 0's and 1's. Then, the hash map data will be generated and then only the original QR Code will be generated.

Normal QR Codes can compress only up to 4 kb of data. Using the techniques followed here, the data capacity can be increased drastically. As compared to the normal QR Codes, the data capacity of the QR Code after following technique was founded and proved to be more than 4 kb. Efficient data compression techniques can be used to store more than 4 Mb of data inside a QR Code. A variety of data compression techniques can be used to obtain more data storage capacity. Comparing with the existing technologies used to generate bar codes, QR Codes were found to be of great advantage to the manufacturer because of its great data storage capacity, reading speed and accuracy. The data capacity was further improved by combining the most distinguishing features of compression and bar code generation. Using this novel technique of data compression followed by data encoding, the data storage capacity of QR Codes were increased drastically.

7. Conclusions

QR Codes are being increasingly noticed on products and in advertisements, and many are still unaware of what the black modules on a white background in a square box stand for. QR code has high data density. The data density was increased even more using the technique of compression of data followed by encoding the data. They can be used to link to any URL [2]. Disadvantage regarding QR code is that users must be equipped with a camera phone and the correct reader software that can scan the image of the QR Code. Currently only Smartphone's are technically equipped to do this. Many users that have mobile phones that have cameras are unable to get QR reading software for their phones. Future enhancements focus on QR Encoding of images which is more than 4 kb of size. Secure QR Coding can also be implemented using encryption techniques. Also, more advanced data compression techniques can be used to add more to the data capacity of the normal QR Codes.

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