Mechanism of QR Code Modulation for Data Transmission in Mobile Devices

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Abstract - *This paper represents 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 the QR image , it causes a blurring effect which reduces the aestheticism and also makes it difficult to decode data at the receiver end. That's why QR image is embedded in HF (High Frequency) cover images. The concept of 2-D barcodes is of great importance for the use in wireless data transmission between two handheld electronic devices. In this study, a new approach for data modulation in 2-D barcodes is introduced, and its performance is evaluated in comparison to other standard methods of barcode modulation systems.*

Key Words: QR codes, Data Transfer, differential phase shift keying, orthogonal frequency-division multiplexing (OFDM) modulation.

1. INTRODUCTION

QR code is a matrix barcode which is used for QR design on embedding icon accommodating extra number of data than its 1D directly. This approach introduces invalid code words in counter part of the system. QR code has the capability of correcting the resultant QR codes where the changeable area is errors since reed Solomon (RS) code have already bounded by error capability, that is the maximum area is been incorporated in it. It is an extensively utilized usually less than 30% of the whole QR area [4, 5]. In order pursuing and identification method in transport, to deal with this problem appearance based QR code production and in retail industries. QR codes are beautifier is proposed [6]. This work involves the highly popular of their high storage capacity and embedment of visual pleasant images in to QR codes speed of decoding. They are used in collection of without violating the specification for decoding. This requests such as accessing websites, download approach eliminates the drawback of visual imbalance but confidential card data, post data to communal webs, the storage capacity is less [6]. Hence to pleasant appearance along with the accuracy of decoded message becomes a major challenge. One of the most common improvise the replicate videos or open text documents. This versatility storage capacity a color QR code generation is proposed, makes them a priceless instrument in each industry where in this paper the visual pleasant appearance along that seeks to involve mobile users from printed materials. with storage space is taken in to consideration. This paper QR code decoding is done based on the visual will demonstrate that the proposed scheme achieves appearance which avoids the additional hardware largest changeable area as compared with existing requirement. Earlier the decoding methods of binary QR approaches. Codes were the Sylvester resultant or grobner basis type.

2. STRUCTURE OF QR CODE

The symbol for a QR code mainly involves the use of black and white square cells also called as "modules" which are placed in a certain position within the symbol for a specific purpose. Figure 2.1 depicts the structure of a QR Code.

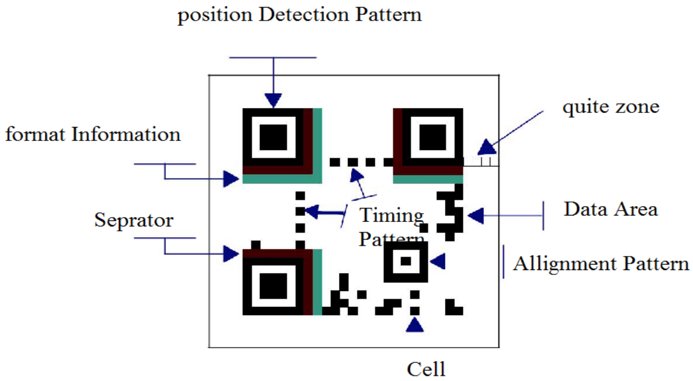


Fig - 2.1: The descriptions and locations of function patterns of a standard QR code

2.1 Quiet zone : It comprises an area of four wide modules, created with the purpose to ease the recognition of the QR code from its background.

2.2 Position detection pattern : It involves three equal structures placed at the three corners of the QR code, namely, top-left, top-right and bottom-left [19].

2.3 Separator : Separator is a white space area with a width of one cell, placed besides the position detection patterns in order to enhance their recognition.

2.4 Timing pattern : It is a sequence of alternating white and black modules that connects the position detection patterns. The timing pattern is used to nd the position of each module in the QR code [19, 20].

2.5 Alignment pattern : This pattern allows to make any correction in the symbol. It consists of three parts: A 5x5 matrix of black modules, a 3x3 matrix of white modules and a single central black module. The alignment pattern is available in version 2 or greater [19].

2.6 Data area : This area refers to the output. At this stage, the error correction codes are included along with the data encoded and a mask pattern is chosen.

2.7 Format information area : The purpose of this area is to store information related to symbol version, error correction level and the mask pattern used to generate the code.

3. RESEARCH METHODOLOGY

This paper presents an application whose main feature is to enable a bidirectional communication. To this purpose we used one main elements namely QR codes. To ensure the correct reception of the image, we required to have a control to coordinate and check the status of the transmission. Since we are using an optical channel for communication, we could not use existing protocols in our application. Therefore, we have designed a protocol, which is inspired by TCP according to the channel used.

The superior performance of the later implementation is achieved using a more effective modulation and coding scheme for mitigation of image blur and pixel to pixel light leakage. The general idea is to use the inverse Fourier transform (IFT) of data like OFDM to modulate pixels. While image blur and light leakage greatly reduce the performance of QR decoders they have a limited effect on OFDM modulation. Furthermore their performance degradation is confined to known portions of the decoded data. This prior knowledge on non-uniform error probability may be used for adaptive error correction coding based on data region. There is an increasing interest in design and implementation of QR based communication systems. This would require additional investigations in determining optimal modulation and demodulation schemes for this type of innovative communications medium. The OFDM modulation uses orthogonal frequency subcarriers to transfer data and can confine image blur, which is essentially a low pass filter, to high frequency components such that low frequency data bits are transmitted intact. This method requires high phase coherency to detect the data bits correctly.

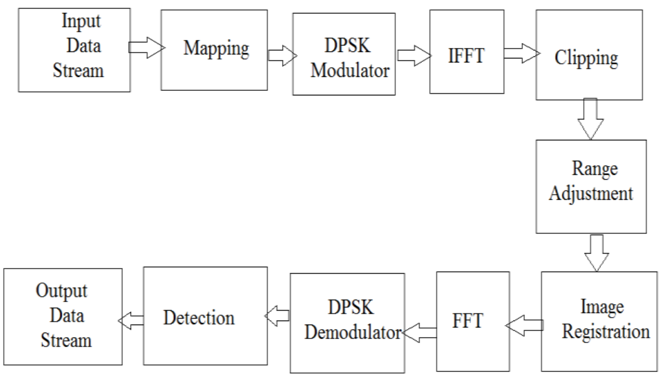


Fig - 3.1: Algorithm Used For Data Transfer

The current study extends this idea through additional modifications on the modulation scheme in such a way to mitigate relative movements during the capture of a single frame, which results in motion blur distortion on the captured images. This kind of distortion as would be detailed later severely degrades the performance of Quadrature Phase Shift Keying (QPSK) modulated OFDM signals. The required movement tolerance is achieved by putting data in phase differences of adjacent frequency components leading to a DPSK-OFDM scheme which would be called simply the DPSK method throughout this study. Observing that any phase distortion due to motion blur would affect neighboring frequency components negligibly, data may be transmitted reliably even in the vicinity of high LCD, camera relative motion. A diagram of the system envisioned is shown in Fig. 3.1. This method also eliminates the channel estimation requirements resulting in lower processing power. To maximize data transmission rate, one should consider extracting maximum data from a single image shown on an LCD and then increase the rate at which consecutive frames will be decoded. In consideration of this issue, any method that is introduced should efficiently utilize the available bandwidth considering motion distortions.

3.1 QR Code Generation :

QR code is a 2D barcode comprising of smallest black and white squares known as modules. Codeword of QR code is 8 bits and each module represents 1 bit where white

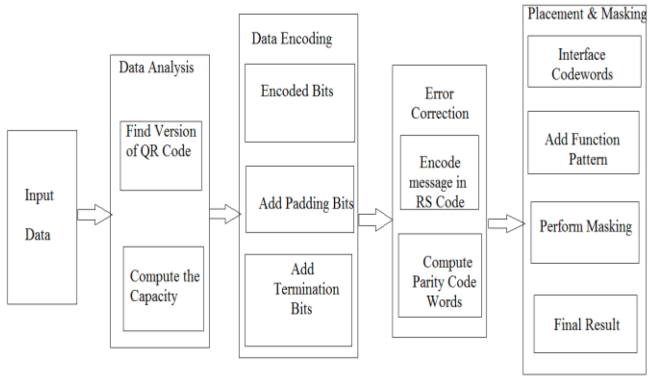


Fig – 3.2: Block diagram for generation of QR code

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<=40 which relates to the size of (17+4V) x (17+4V).

3.1.1 Data Analysis:

In this stage, the input data is analysed for segregate function patterns from encoded pattern of compression and also for the determination of error information. Fig. 3. shows masking patterns that are used correction level. The suitable version is decided in this in QR code generation [7]. stage.

3.1.2 Data Encoding:

This stage involves encoding data in a corresponding selected encoding mode. 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.

3.1.3 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). 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.

Table 1: Error Tolerance Table

Error Level	Data Recovery
low	7%
Medium	15%
Quarter	25%
High	30%

3.1.4 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 error information. Fig. 3.2 shows masking patterns that are used.

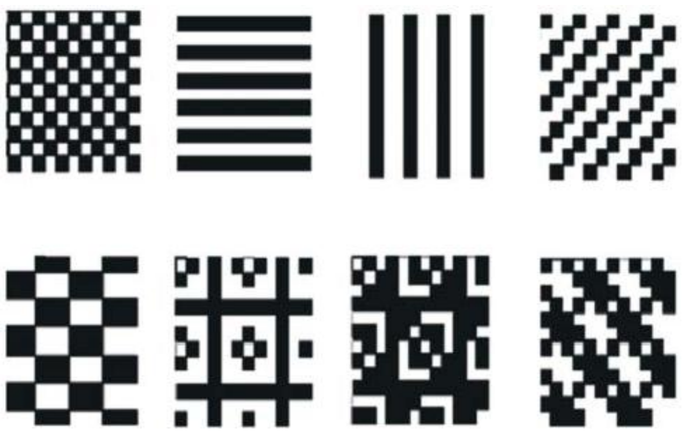


Fig – 3.3 Masking Patterns for different error correction code

4. SIMULATION

This paper aims to implement an application to enable bi-directional data exchange. To this purpose, a communication protocol was designed in order to set the rules for providing feedback during transmission and also to facilitate reconstruction when the transmission is over. This paper details the system design, the software components used, the protocol design and its operation.

Current 2D barcodes use PAM as the preferred modulation method [2]. To compare them with the proposed modulator and demodulator, both systems are implemented in MATLAB. A Simple PAM modulator which translates bits into light and dark pixels of an image is compared to the proposed DPSK-OFDM method which uses the described algorithm for modulation and demodulation. Furthermore, the performance of QPSK-OFDM, which is essentially the same as 4-QAM (Quadrature Amplitude Modulation) OFDM used in PixNet [5], is compared to the proposed DPSK-OFDM system. The main parameters that are considered include:

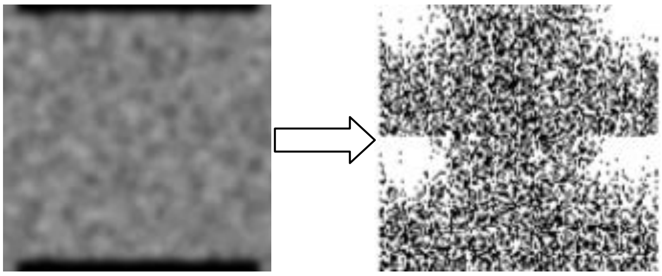
- noise and clip ratio;
- low pass filtering;
- camera movement.

To study the effect of each of these parameters, first a random data stream is modulated to the displayed image using the algorithm under test. Then a controlled distortion is applied to the image before passing it to the receiver. The bit stream at the output of the decoder is compared to the input random stream to count for erroneous bits. This process is repeated several times using various random data streams and the same amount of distortion. The average result would be the bit error rate corresponding to that particular situation and assumed distortion. The process is then repeated for another distortion amount resulting in a plot for bit error rate against distortion.

A. Noise and Clip Ratio

In a barcode setup where PAM is used to modulate data onto image pixels, the average power is maximized. Consider the maximum amplitude driving a fully "on" pixel is leading to a transmitted energy.

It can be observed in these plots that the BER increases with lower cutoff frequencies. Here defines the cutoff frequency as a percentage of image width. It can be seen that unless the cutoff frequency is less than 20%, frequency domain modulations have better error performance than the PAM method. To show the errors both in real and imaginary parts of image, the lower half of provides errors in the imaginary part of while the upper part indicates errors in the real part of figure. The generated pattern is shown in Fig-4.1 (b), An interesting point that can be seen here is that unlike PAM modulation, the location of error bits are not distributed randomly. In fact error bits are more concentrated in the high frequency areas of the OFDM based modulation methods.



(a) DPSK Modulated Signal (b) Location of error Bits

Fig- 4.1 QR Image and Location of its Error bits

B. Low Pass Filtering

Inter symbol interference and out of focus lens may be modeled by applying low pass filtering on the captured image. To simulate this out of focus effect, the Butterworth low pass filter in the frequency domain is used with various cutoff frequencies and the resulting BER is measured.

C. Camera Movement

Assuming linear image motion in and directions and instantaneous shutter opening and closing, the motion may be modeled by the following transfer function as described.

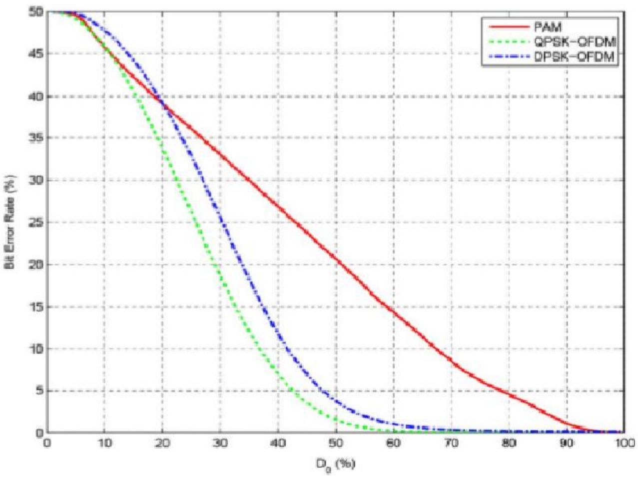


Fig- 4.2 Effect of LPF Which Shows DPSK-OFDM Method is Better than PAM Method

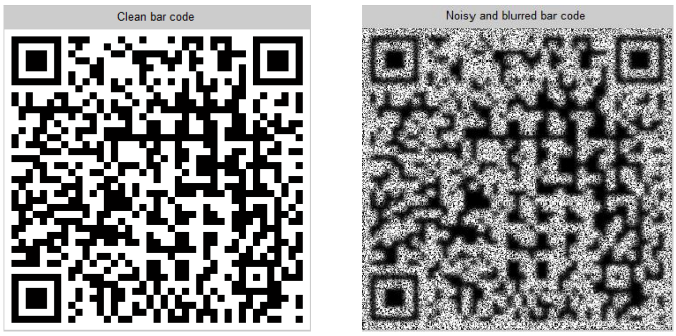
In the proposed DPSK-OFDM method BER is maximized as reaches about its maximum value. This is the case where the motion is perpendicular to the differential phase modulation path. Because vertical phase difference of the elements is what transfers data, if the movement is in the vertical direction, then errors may emerge. On the other hand, if the movement is horizontal it is not going to change the phase differences of elements in two consecutive rows, thus no error is generated (the errors, if any, in that case will be due to amplitude attenuation). Exact vertical movement has slightly less error rate. Due to the fact that the first row is modulated horizontally and vertical movement has minimal effect on it.

This is why DPSK modulated OFDM signal shows its promising capabilities in mitigating aggressive relative movements. it should be noted PAM modulation is using 5 dB more average power than that of the proposed OFDM and DPSK methods. Hence it should be noted that in PAM modulation is using about 5 dB or more average power than OFDM and DPSK modulation method.

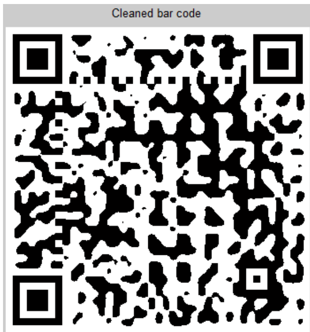
5. RESULT

Hence in this paper we have seen that the result obtained are far better as compared to the blurring image of the QR Code which needs to be maximized at the end the barcode which we have design can give the graphical importance of memorization and organizing of data related to the conceptual analysis of BARCODE code which can be further realized and converted into QR Code. This System can be effectively used for LTE system or any another 5G Technology.

The figure 4.2 shows the result of QR code when inputted as a clean QR code (a), when noise get mixed up into the QR code (b), and after removing noise from the QR code code we get cleaned QR Code at (c).



(a) Clean QR Code (b) Noisy and Blurred QR Code



(c) Cleaned QR Code

Fig – 4.2 Output images of QR code after removing noise

6. CONCLUSION

In this paper, the DPSK-OFDM technique has been presented. The presented technique performance in terms of QR code has been shown to be very similar to the matching technique and its computational complexity such as mitigation of camera, movements of display has been decreased.

This enhancement during the preprocessing step implies an effective gain of complexity in LTE context in which it has been shown that the mean error rate is higher than this announced threshold. This technique will maintain an error rate less than 7% to 8% which is practically correctable using error correction coding algorithms.

This work can extend the usage in authentication field as well in various multimedia application. Also the current BER performance evaluation needs to be improved.

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