A Review on Image Encryption using QR-Code

Dr. Jyoti Bharti* and Akanksha Sahu**
* Dept. of C.S.E., MANIT, Bhopal
jyoti2202@gmail.com
** Dept. of C.S.E., MANIT, Bhopal
aakanksha0892@gmail.com

Abstract: With the increase in exchange of digital image, security of information has become important and necessary in image storage and transmission. As the image or picture is being used for industrial purpose, it is essential to protect secret image data from illegal access. Recently, Quick Response Codes are being considered as a successful way to safely share data and information. This paper evaluates several techniques for Image Encryption for transmitting information securely using QR Code. The paper also compares distortion value and correlation among pixel values.

Keywords: Image, Encryption, Attacks, QR-Code, Security.

Introduction

Due to enormous growth in communication technology, information sharing through the network have never been so convenient. Only from last some years, information is handle electronically and transmitted over public networks. Transmission over public network is unsecure and hence it is necessary to secure sensitive information by some means. Ref. [1] Now-a-days, sharing document or data over internet is increasing globally, therefore security is extremely essential for digital information exchange. Security attacks are mainly categorized as: Active and Passive Attacks. Active Attacks, involves tempering of the raw data or building of false stream. Passive Attacks, involves eaves dropping, or monitoring the transmission. Active attack attempt to harm the system whereas, Passive attack involves monitoring of unsecured communication and traffic analysis. Therefore, we have to spot new ways to counter these security threats. In the paper, the potential of QR-Code as a mechanism to secure information through the network by encrypting the image has been reviewed.

Ref. [2] Encryption is an security method for image. Image encryption is a technique to convert an actual or original image to another image (ciphered image) that is hard to interpret and unreadable to naked eyes, without any particular knowledge (as shown in Fig. 1). The process of reconstructing encrypted (cipher) image to plain image is called Decryption. Image encryption have usage in different fields such as: military communication, Tele-medicine, multimedia systems and internet communication. Ref. [2] Due to the built-in features of the image, for example, data storage capacity, the strong concurrency among pixel values, traditional algorithms are not good for encryption of image as they give inefficient results. In recent years, various image encryption ways has been suggested. Until now, variety of algorithms for data encryption have been presented and broadly used for example AES, RSA, or IDEA where few of them are already used in the text or binary data.

Recently, QR Code has been used widely for secure image transfer. QR Code a 2D barcode was discovered by Denso-Wave, a Japanese firm, to good attribute set of 2D Code such as high data capacity, high-speed scan, good data recovering capability, etc., and they are widely used.

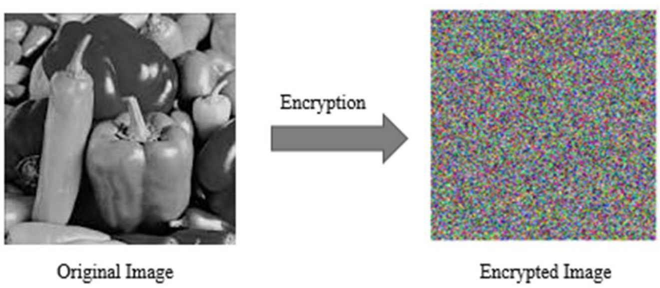

Figure1. Encryption Process

This paper briefs about the basic understanding of QR code and Literature Review done in all techniques of diverse fields for transmission of image securely and also for the research is detailed in section II. In section III analysis is performed and section IV presents the conclusion.

Understanding QR-CODE

QR-Code or 2D code

2D codes have overtaken the recognition of long-established barcode in several areas due to many advantages like increase in capability, small size, etc. Along with variety and extendibility rendered, making the usage of QR code further important than 1D barcodes. Ref. [3] Information in the QR code is inserted in two directions, horizontally and vertically, holding up to few hundred times extra data than 1D barcode as shown in Fig. 2. A user can get the data by clicking a picture of QR code utilizing a standard camera (e.g. available in a smartphones) and using QR reader to process the image. Two-dimensional (2D) barcode is more secure than one-dimensional barcode (1D). 1D barcodes can be interpreted simply scanning the spaces and the lines, whereas 2D codes are difficult for human eyes to read. For reading a 1D barcode they must be scanned along single direction whereas 2D barcodes can be scanned in any direction. Therefore, 2D barcodes are readable.

Architecture of QR-Code

Ref. [3] There are 40 different versions of the QR code of different sizes, starting with version 1 having 21×21 modules up to version 40 having 177×177 modules. 2D code comprises of different areas that are filled for fixed purposes. In Fig. 3 different areas are mentioned:

- Finder Pattern: It consists of 3 similar shapes placed at the corners of QR Code eliminating the bottom right side. Each pattern consists of a 3x3 matrix black module, the black module is surrounded by the white module which is again covered by the black modules. This pattern helps to deduce accurate orientation and in recognizing the QR code by decoder software.
- Separators: The width of white separators is one pixel separating the data from the Finder Patterns.
- Timing Pattern: Timing Pattern sits between two finder patterns enabling the decoding software in recognizing single module's width.
- Alignment Patterns: Alignment Patterns consists of one central dark module, surrounded by 3 x 3 light modules and by 5 x 5 dark modules at the end. Decoder software using the help of alignment pattern, decodes the code even if the code is distorted.
- Format Information: This section stores the knowledge regarding error correction level and masking pattern of the QR Code, consisting of 15 bits and lies next to the separators.
- Data: Data is stored in grouping 8 bit in the data section after converting the data into the bit stream.
- Error Correction: Code words are also stored with data words for correcting error when an error is detected.
- Remainder Bits: Remainder Bits consists of empty bits if data and bits of error correction code bits can't be completely divisible into an 8-bit code word.
- Quiet Zone: QR Code has an outer boundary used for separating the 2 dimensional barcode from an external area.
- QR code composed of Reed-Solomon codes for correcting error and there are 4 classes of error correction level i.e. L, M, Q and H.

Figure2. 1D Barcode and 2D Barcode [3]

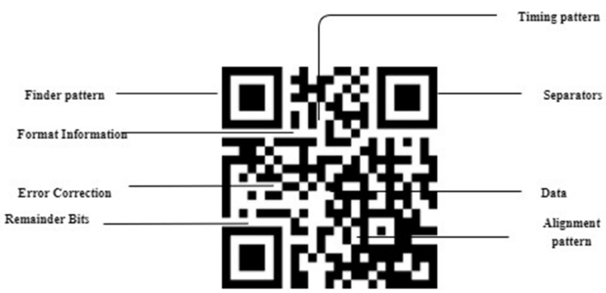

Figure3. QR-Code [3]

Literature Review

This section list the different types of methodology used for security of image like block-based transformation, DS, affine transformation with XOR, techniques using QR code with multiresolution technique, binarization, etc. These are discussed below:

Block-Based Transformation Technique

Ref. [4] The authors recommended a new algorithm called block-based transformation by combining the image transformation & blowfish algorithm. Firstly, the image is splitted into several blocks and rearranged utilizing the image transformation algorithm, and at the end encryption algorithm blowfish is applied to the transformed image and in results they got lower correlation. As analysis was done, shows that expanding the count of blocks by decreasing the size of block results in less correlation and thus greater percentage of entropy is achieved.

Digital Signature Approach

Ref. [5] The authors suggested a modern technique for secure image in which along with the encoded version of Original image, the digital signature is also added. One of the finest error code follows the encoding of the image, ex Bose-Chaudhuri Hochquenghem (BCH) code. After decryption at the receivers end, the image's authenticity is verified using digital signature.

Permutation Approach in combination with Encryption

Ref. [6] The author suggested a modern encryption technique, a new permutation procedure based on the fusion of image permutation and famous encryption algorithm RijnDael. The actual image was splitted into 4 pixels x 4 pixels pieces, which were rearranged to a permuted picture making use of permutation procedure, and afterward the permuted picture was encoded using RijnDael algorithm. As a result, the suggested procedure signify that the factor correlation between image's elements was decreased and higher entropy was achieved.

Affine Transform with XOR Operation

Ref. [7] The author provided a new approach for encrypting image using affine transform based on rearrangement of image pixels. The procedure suggested was splitted into encryption & decryption algorithm. The very first step consists of applying XOR operation to encrypt the image and using 4-bit key and applying affine transformation, i.e. shuffling the pixel values to relocate to different locations. Next, the transformed image is splitted into 2 pixels x 2 pixels block, and then applying XOR operation to encrypt each block using 4 bit key. The outcome obtained shows that after applying affine transform, correlation factor among pixel values was notably reduced.

QR-Barcode Techniques for Image Security

Ref. [8] The authors presents nested steganography scheme constructed using 2D code and different techniques of image processing. In the approach proposed, lossless data in the form of text encoded by QR barcode is embedded into the cover image. Comparing the data with extracted data and original image, there was no distortion exists in data. The error correction rate of QR encoding is need to design carefully, as the data extracted is lossless. It was found that error correction rate of 25% will be perfect for the aim. As a result, the proposed plan was robust to jpeg attacks.

Ref. [9] The authors Zhang provides a new method for solving the problem of QR code recognition due to collection images of ordinary camera, the recognition algorithm established on image processing. The complete process include image binarization, image tilt correction, image orientation, image tilt correction, image orientation, image geometric correction, different acquisition angles to be identified quickly. Improvements are suggested in the previously defined methods by considering other algorithms to improve processing speed of image processing. The results are that enhanced method increases the recognition speed of 2D-code and accuracy by 6.45 times the previous.

Image Embedding approach in QR-code

Ref. [10] The author introduces a process for minimizing visual distortion in QR images. The algorithm proposed forms the basis by selecting a set of updated pixels using the algorithm multiresolution halftoning mask. Then using non-uniform programming techniques pixel value of images are turned into luminance level, thus producing less visual distorted QR image. The experimental outcome shows that the suggested QR code with color image has reduced distortion rate, MSE, MSSIM and processing time than existing methods.

Ref. [11] In the paper presents a procedure to embed 2D code into color images, premising to automatically create embeddings with little probability of detecting error for a given noise power. These embeddings are suitable with ideal decoding applications and can be applied to all type of images with full coverage of area. Luminance values of the image was used to encode the QR information bits. To reduce the visual distortion value in QR image, the algorithm proposed uses half toning masks for selecting modified pixels, then locally optimizing luminance level applying nonlinear programming

techniques. The method developed is applicable only to produce binary halftones not for embeddings of multilevel halftones. The outcome of experiments done shows dignified degradation of the decoding rate.
Ref. [12] The authors proposes a process of embedding image in QR code, in which the appearance of QR code composed of visually purposeful patterns chosen by users. To enhance the visuality of QR code, modification methods are largely used. All the methods either use error correcting potential of the code or the methods are based on heuristics approach. The main area of focus is QR code should be comfortably decoded by standard applications. To maintain the decoding capability of embedded QR code, the proportion of color image to the section of embedding should be proportional or equal to correcting capacity of code. This method reduces robustness of code but can be controlled by changing the peak value of probability of error. The work proposed embeds image into entire region of the code and gives better results than the previous methods.

Appearance-Based QR Code Beautifier
Ref. [13] The authors presents a standard way to beautify QR code. For overcoming the noise like appearance of QR codes, the authors proposes, QR code beautifier framework, where 2D code consists of visually key patterns chosen by users. They had done subjective, along with objective metric evaluation to show the superiority of the discovered method. The work greatly improved the aesthetic views of the user and makes the mobile multimedia application more pleasant.

Analysis

It can be analyzed that for better strength or magnitude of security for encrypted images, various properties of image plays different role, where for better security it is analyzed from the survey done that correlation is very important. If the correlation among pixels is less than image is more secure. Ref. [5], Ref. [6], Ref. [7] The techniques discussed in these paper provide the results by taking correlation value into consideration and showed that less correlation value is obtained after applying the algorithm (shown in Table 1). Ref. [5] In paper, the author has used optical correlator or digital correlator to simulate the results and sharp correlation peak is obtained which shows that image is not tampered. Ref. [6] In paper, the author has derived a relationship between correlation value, entropy and image block size. By increasing the block number i.e by reducing the block size results in less correlation among pixel value and thus higher entropy value. The results are described in Table 1, where I_1, I_2, I_3, I_4 refers to original image (300 x 300 pixels bmp image with 256 colors), ciphered image after applying RijnDael algorithm, image obtained by permutation operation and ciphered image combining permutation with RijnDael algorithm The relation obtained is shown in equation 1 and equation 2.

$$\text{Small Block Size} \propto \text{Less Correlation value} \tag{1}$$
$$\text{Less Correlation Value} \propto \text{Higher Entropy value} \tag{2}$$

Ref. [7] In paper, the authors has applied affine transformation to the original image to break the correlation among pixel by transforming the pixel to other locations, as it the weak point for security and at the applied XOR operation to make the image meaningless. Then encrypted the image taking into attention the small block size for better security. The Table 1 describes the correlation after affine transformation and after encryption with XOR operation.
Ref. [10] The another important factor surveyed from this paper is the distortion value of encrypted image by taking different QR version. There are various ways to embed important images into colored images using QR code such halftoning techniques for selecting modified pixels and then transforming image pixel values to luminance value undetectable to naked eyes resulting in less distorted decode image. The results are described in Table 2, provides that less distortion is provided applying QR code in the method. Ref. [15] The method 'A' is Non Systematic encoding of RS code and method 'B' is the Appearance Based QR-code Modifier method.
The methods in paper [9], [10], [11], [12] focuses on image embedding in QR-code, how the embedding can be done in best way with less visual distortion, good decoding capability. Ref. [10] The Table 2 also describes the distortion value using color code embedding. To decode the image successfully or maintaining the decoding capability, ratio of color image to the code should be equivalent to error correction capacity. The one main issues in embedding image in QR code is in selecting the right and best class of modules in QR code. One of the embedding method is choosing the central pixels of each of the modified modules, modifying the luminance value. Ref. [14] But this method results in inadequate visual distortion, that can be solved if selecting the center pixel value based on average luminance of pixels and the threshold set as written in the paper and where some techniques focuses on QR code recognition, i.e how to make QR code appear smooth at receiver end and found that applying Image binarization, seeking, tilt correction, etc. improves the image appearance and processing time.

Table 1. Comparison of Correlation value and Entropy

S. No.	Method	Image	Metrics	Key Size	I_1	I_2	I_3	I_4
1	Ref. [6] Permutation Combination Technique	Bmp image of 300 x 300 pixels , 4 x 4 block size	Correlation Value	8 Byte	0.858	0.0045	0.5714	0.0022
				16 Byte	0.858	0.0043	0.5684	0.0029
				32 Byte	0.858	.0018	0.6224	.0012
			Entropy	8 Byte	2.6463	5.5436	2.6463	2.5436
				16 Byte	2.6436	5.5437	2.6463	2.5438
				32 Byte	2.6463	5.5435	2.6463	5.5436
2	Ref. [7] Affine Transform and XOR operation				Affine Transformed Image		XOR Image	
		Lena (256 x 256 pixels)	Correlation Value	1 Byte	0.9468		0.5088	
		Xplane (256x 256 pixels)			0.9283		0.4983	
		Airplane (256 x 256 pixels)			0.9971		0.2873	

Table 2. Comparison of Distortion Value

S. No.	Methods		Distortion Value			
		QR Code Version	In salient region (%) with Lower Error correction		In salient region (%) with Higher error correction	
			Method A	Method B	Method A	Method B
1	Ref. [14] Based on QR code appearance	15	30.63	1.90	38.12	25.87
		25	31.74	1.67	39.15	28.93
		35	31.81	1.26	39.47	29.91
2	Ref. [11] Color Code Embedding	Image	Multi Resolution Technique		Halftoning Technique	
		Image 1	0.34		0.38	
		Image 2	0.35		0.37	
		Image 3	0.34		0.38	

Conclusion

In today's world, the security of both binary and electronic images has become very much important since digital products are communicated through network very frequently. In the review paper, we performed survey of existing work on image encryption. We also give general guide line about cryptography. The conclusion we got after the survey, every technique is useful for real-time image encryption. Techniques describes here in the paper that can provide security functions and an overall visual check, which might be suitable in some applications and for real life applications too.

In general, fast and strong 2D Barcode if chosen will provides higher security for digital data or e-data.

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