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QR Code Based Image Steganography

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Abstract: Image Steganography is the process of embedding secret data in images such that its existence cannot be detected by others apart from the sender and the receiver. The present work focuses on a combination of cryptography and steganography to secure the data while transmitting over the network. This paper presents image steganography using Block based Discrete Wavelet transform for embedding of the encoded secret message using Quick Response Code (QR) code into the image while embedding process is further protected by Advanced Encryption Standard (AES) cipher algorithm. The efficiency of the proposed method was measured by Peak Signal-to-Noise Ratio (PSNR).

Keywords: Steganography, DWT, QR code, AES, Payload, PSNR.

I. INTRODUCTION

Steganography is the art and science of hiding the existence of the communication, i.e., it hides the secret message inside the other medium like images, audio, video, text, etc. It is defined as the process of writing messages in a way in which the presence of a secret message is not known to anyone apart from sender and receiver.

The paper present how QR Codes (commonly known as 'Quick Respond Codes') used in the field of Cryptography. QR Codes are mainly used to convey or store messages because they have higher or large storage capacity than any other normal barcodes. The paper describes how QR Code is used for image steganography. Since QR Codes have a fast response time and have large storage capacity, QR Codes can be used perfectly to send encrypted data (messages) to the receiver. The block based DWT algorithm is used for the steganography and additional security is achieved by applying AES cryptography to the QR code before embedding it into the cover image.

II. LITERATURE REVIEW

In this section, the works carried out by various researchers are as follows:
Vladimír Hajduk, Martin Broda, Ondrej Ková, Dušan Levický has focused on the proposal of image steganography method that is able to the embedding of the encoded secret message using Quick Response Code (QR) code into image data [1].
Akshara Gaikwad, K.R.Singh has proposed embedding methods for the use of halftoning method to distribute the modified pixels of QR code which is to be embedded into a color image, so that it should not be visible to naked eye on the color image. This paper aims at explaining QR code structure, the different patterns involved in a QR code image, the basic steps of information hiding using QR code, QR code embedding in color images and basic steps of QR decoding process [2].

Hamad A. Al-Korbi, Ali Al-Ataby, Majid A. Al-Taee and Waleed Al-Nuaimy have introduced Wavelet transform. The Haar DWT is used in the proposed steganography technique. It is the simplest transform in wavelet mathematics because it uses square pulses to approximate the original function [3].

Manoj S. Rewatkar and Shital A. Raut also introduces the paper which presents the survey on information hiding techniques which can share high-security information over a network using QR barcode. They have also proposed the structure, feature and information hiding process in QR code [5].

B. Padmavathi, S. Ranjitha Kumari have proposed three encryption algorithm i.e. DES, AES, and RSA. Also, they have compared DES, AES and RSA encryption technique based on different parameters such as performance, scalability, speed etc. to encrypt a data or document [7].

Mohammad Ali Bani Younes and Aman Jantan has focused on the method to exchange the information between the sender and the target receiver [8].
Prabakaran, G.; Bhavani, R.; Sankaran, S. have proposed a robust method of embedding QR code into the DWT domain of divided blocks of the still image [10].

III.PROPOSED METHOD

The proposed system introduces a Steganography method based on Quick Response (QR-code) and Block based Haar Discrete Wavelet Transform (DWT) [6, 3]. This technique includes encoding and decoding operation in the frequency domain. The text message to be transferred is hidden in the QR-code image. The QR code image is hidden into the Discrete Wavelet Transform. This technique performed well and additional security is given to the embedded information by using AES algorithm for cryptography.

The proposed technique hide secret text in QR code, before hiding the QR code inside the cover image, the QR is saved as a black and white image with 1 bit per pixel and is stored in an array of bytes to be encrypted using AES before embedding it inside the cover image. AES is a most suitable algorithm for encryption when it compares with other encryption algorithms [7].
The Fig. 1 represents the Block Diagram of Proposed System.

A. Block Based Discrete Wavelet Transform

One of the most developed transforms that can be used to transform a signal from the spatial to the frequency domain and vice versa is the Wavelet transform. Wavelets are defined as oscillations of short waves that decay rapidly over time [3]. Moreover, they have an enormous number of applications that can be implemented in various fields such as signal processing, data compressing, fingerprint verification, smoothing, image de-noising and speech recognition. It has been reported that the Wavelet transform can be applied to the steganography technique in order to increase the capacity as well as the robustness [3]. One of the Wavelet transform families known as "Haar" has been implemented in this work. It converts an image from the spatial domain to frequency domain by applying horizontal and vertical operations, respectively.

The Block Based Haar DWT is used in the proposed steganography technique. It is the simplest transform in wavelet mathematics because it uses square pulses to approximate the original function. DWT is used to convert the cover image into four sub-bands which are an approximation, vertical, horizontal and diagonal coefficients. These bands represent low-low, high-low, low-high and high-high frequencies, respectively. Approximation coefficients will not be used to conceal secret information since human eyes are very sensitive to small changes in the low-low frequency. However, the rest of the coefficients contain high frequencies, thus secret data will be corrected and concealed within these bands by the use of both least significant bit and pseudo random number techniques. After the embedding process is completed, the inverse Haar DWT is applied in order to form the stego image and then the further steganography procedure is carried out.

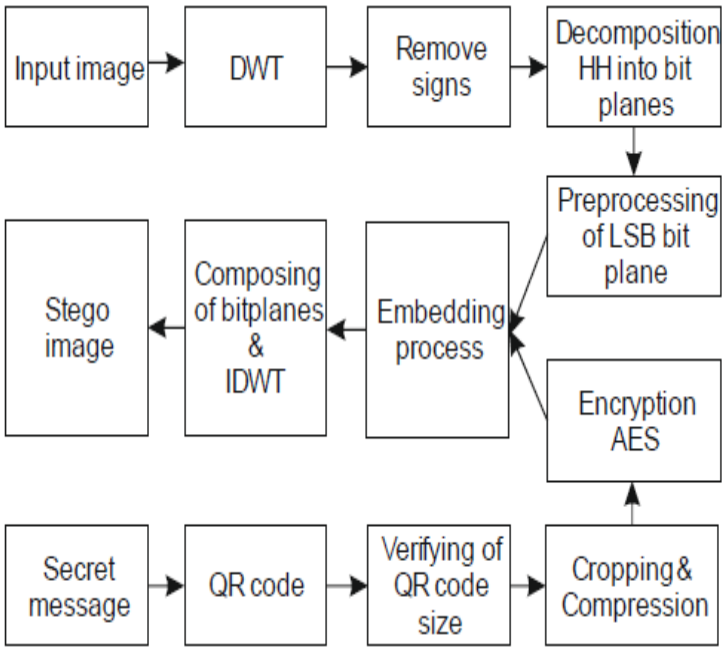

Fig.1 Block Diagram of Proposed System

B. QR Code

QR Code (Quick Response Code) is a special type of two-dimensional barcode designed by Japanese automobile industry. The idea was first proposed by Denso Wave, QR Code is usually attached to an item and it contains information about that item, information can be in form of numeric data, alphanumeric and binary, this makes the QR Code capable of storing theoretically any kind of data as long as they are represented in binary. QR Code system has fast readability and great storage capacity which made it popular outside the automotive industry, it is made of black dots arranged in a matrix-like order with a white background, and this design makes it easier for imaging devices to capture, correct and interpret data stored in QR Codes. QR code consists of the functionality patterns for making it easily decodable which are described in [5].

C. Embedding Process

Embedding process is nothing but hiding secret QR code image inside the cover image using Block Based DWT. The obtained image after embedding process is stage image [2].

Embedding process of secret message in form of QR code is implemented by using following steps which are also illustrated in the Fig.2.

1) Loading input data, image and QR code.
2) Verifying of QR code size.
3) Cropping of white space from QR code (four bits from every side). Subsequently, each module of same adjacent bits in the QR code is replaced by one bit with the specific value from this module in order to compression of QR code. The size of the module depends on the user option.
4) Obtaining of cropped QR code size. This size information will be inserted into transformation coefficients of the image as first.
5) The input image is transformed into LDWT domain by Haar wavelets (four sub-images LL, LH, HL, and HH).
6) Determine the size of sub-image HH, where is embedded secret message.
7) The signs of specific transformation coefficients are stored in sign matrix.
8) Subsequently, the signs of transformation coefficients are removed and sub image HH is decomposed into 8-bit planes.

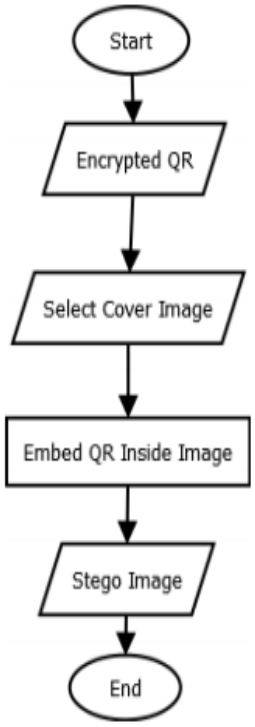

Fig.2 Flowchart of Embedding Process

9) QR code embedding is performed in LSB bit plane of HH sub image, where LSB bits are replaced by encrypted bits of QR code. Bit substitution is implemented from the third row and second column of matrix HH because of preservation of statistical features of the image.
10) After embedding, modified LSB bit plane is composed into HH sub-image.
11) Inverse DWT is applied on modified sub image HH and original HL, LL an LH sub-images.
12) After implementation of these steps, stego images with embedded secret message in form of QR code is created.

D. Extraction Process

Secret message in form of QR code can be obtained from stego image by extraction algorithm of proposed steganography method. This process is based on inversion operations considering embedding algorithm. Finally, obtained QR code can be read by an imaging device (i.e. smartphone), where a secret message in text or data form is acquired.

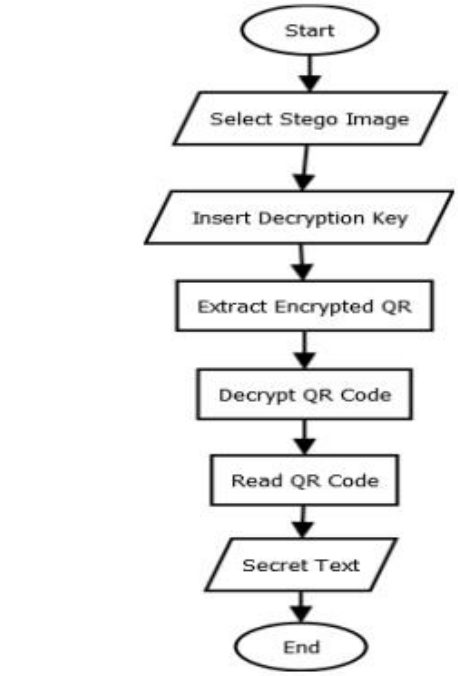

Fig.3 Extraction Process

IV. RESULTS AND DISCUSSION

The efficiency of the proposed technique is measured by RMSE and Peak Signal-to-Noise Ratio (PSNR) for different versions of QR code with different payloads and different sizes of cover images.

The PSNR values were obtained by comparison cover and stego versions of three well-known images (Lena, Baboon and Babra). The number of characters coded by QR code is dependent not only on the version of QR code but also on the data type. The maximum storage capacities for different data types and for the highest level of QR code (version 1, error correction level L) is illustrated in TABLE I.

TABLE I. Maximum storage capacities of QR code (version 1)

Input data	Max. characters	Possible characters
Numeric only	41	0,1,2...9
Alphanumeric	25	0–9, A–Z, space, $, %, *, +, -, ., /, :
Binary/Byte	17	ISO 8859-1

Experimental results show, that PSNR of our proposed method achieves higher values providing using QR code with higher capacity. These results are illustrated in TABLE II and TABLE III with different sizes of QR code with version 1.

In this experiment QR code of version 1 with different payload and its embedding using Block based DWT in the different sizes cover images are verified and PSNR value is calculated for the same which is shown in following TABLE II and TABLE III. Hence the following tables show the average results of 150 images.

TABLE II. PSNR values of stage images for proposed steganography method with the 25*25 size of QR code image.

Image	Image Size	PSNR	MSE
Lena	256*256	118.501	0.464155
	840*840	140.772	0.0500533
	1024*1024	142.941	0.0402933
Baboon	256*256	112.168	0.874389
	840*840	127.613	0.186597
	1024*1024	137.365	0.070368
Babra	256*256	98.1823	3.5406
	840*840	131.969	0.125712
	1024*1024	136.991	0.073050

TABLE III. PSNR values of stego images for proposed steganography method with 50*50 size of QR code image.

Image	Image Size	PSNR	MSE
Lena	256*256	88.809	9.03975
	840*840	135.760	0.082618
	1024*1024	137.607	0.068688
Baboon	256*256	86.7004	11.1617
	840*840	118.501	0.464155
	1024*1024	136.803	0.074442
Babra	256*256	72.7508846	0.004122
	840*840	98.1823	3.5406
	1024*1024	131.969	0.125712

Following experiment is performed on Babra image shown in Fig.4, embedding a text of length 600 Characters, the embedding was performed using the proposed technique.

Cover Image **Stego Image**

Fig. 4 Experimental Images

Above experiments on different size cover images with different payload sizes gives the high PSNR value with a high payload of data.

CONCLUSION

In this paper, a high-capacity image steganography algorithm based on Haar wavelet transform that is capable of hiding various data of different size has been presented. All these of private data are concealed in stego images. The stego image is formed to be always equal to the cover image. Experimental evaluation has proven that the proposed steganography is highly efficient in terms of the capacity size of the cover image while maintaining a relatively low MSE and high PSNR.

Future work will focus on extending the proposed method for Kekre's Image Steganography algorithm and a comparison analysis between various image steganography methods.

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