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IMAGE COMPRESSION TECHNIQUE FOR QUANTIZED ENCRYPTED IMAGES USING SVD

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Abstract -*A lossy compression technique for encrypted images using Discrete Wavelet Transform (DWT), Singular Value Decomposition (SVD) and Huffman coding is analyzed in this paper. At the sender side first the image is encrypted by using quantized wavelet coefficients and secret key. In the image selection of significant and less significant coefficients are performed by using the wavelet domain. Encrypted LL sub-band data is quantized and compressed by Huffman coding while; other sub-bands encrypted data is efficiently compressed by discarding irrelevant information using SVD and compressed by Huffman coding techniques. At receiver side, a reliable decompression and decryption technique is used to reconstruct the original image content with the help of compressed bit streams and inverse quantization & secret key. The proposed method is evaluated using parameters such as Compression Ratio (CR) and Peak-Signal-to-Noise Ratio (PSNR). This scheme has an advantage of using SVD due to which we have obtained good compression performance while retaining the desirable features of the reconstructed image.*

***Key Words*: Compression ratio, Quantized image coefficients (QIC), Quantized wavelet coefficients (QWC), discrete wavelet transform, Huffman coding, Singular value decomposition, Image compression, Peak signal to noise ratio.**

1. INTROUCTION

Image compression is an application of data compression that encodes the original image with few bits. The objective of image compression is to reduce the redundancy of the image and to store or transmit data in an efficient form. The main goal of such system is to reduce the storage quantity as much as possible, and the decoded image displayed in the monitor can be similar to the original image as much as can be. The rapid increase in of transmitting images in social networking sites has raised two problems like secure transmission and large size of image. To rectify this problem we need quantized & encrypt the image and then compression the image.

Lossy compression for Gaussian source can be achieved through Wyner–Ziv theorem [1]. Recently, a prediction error based ETC technique is proposed by Vaish et al. [2]in which prediction errors are calculated by using a sub-image and efficient compression is achieved by using quantization and Huffman coding. More recently, an efficient compression of encrypted image using wavelet difference coding is given by Kumar and Vaish [3].In this paper, a lossy ETC technique is proposed through which good compression performance can be achieved while ensuring the security of images.

2. RELATED WORK

2.1 Singular value decomposition

SVD does is split a matrix into three important sub matrices to represent the data. Given the matrix A, where the size of a is $m \times n$ where m represents the number of rows in the matrix, and n represents the number of columns, A can be broken down into three sub matrices $A = USV^T$ where U is of size $m \times m$, S is of size $m \times n$ and is diagonal, and V^T is of size $n \times n$.

$$U_{m\times n}=U_{m\times n}\times S_{m\times n}\times (V_{n\times n})^T \qquad (1)$$

$$S_{m\times n}=[S'_{c\times d} \ldots 0;\ 0 \ldots 0],\ c \le m,\ d \le n \qquad (2)$$

As S' has less number of rows and columns with respect to S, therefore, to make matrix multiplication possible some columns of U and rows of V need to be reduced as given below in eq.(3):

$$U_{m\times m}= U'_{m\times c}\times U'_{m\times (m-c)}$$

$$\text{and } V_{n\times n} = V'_{n\times d} \times V'_{n\times (n-d)} \qquad (3)$$

Hence the reconstructed matrix can be obtained as:

$$T'_{m\times n} = U'_{m\times c} \times S'_{c\times d} \times (V'_{n\times n})^T \qquad (4)$$

Since the singular matrix stores singular values (in descending order) therefore by the use of psychovisual concept, ignoring the lower singular values will not significantly reduce the visual quality of the image [5].

2.2 Discrete Wavelet Transform

At first, the input image will be filtered into lowpass and highpass components through analysis filters. After filtering, the data amount of the lowpass and highpass components will become twice that of the original signal; therefore, the lowpass and highpass components must be downsampled to reduce the data quantity. At the receiver, the received data must be upsampled to approximate the original signal. Finally, the upsampled signal passes the synthesis filters and is added to form the reconstructed approximation signal.

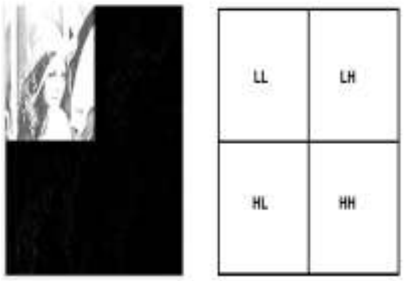

Figure (1) One level wavelet decomposition

3. PROPOSED METHOD

Block diagram of proposed ETC technique is demonstrated in Fig.2, and the complete process is summarized in the following subsections.

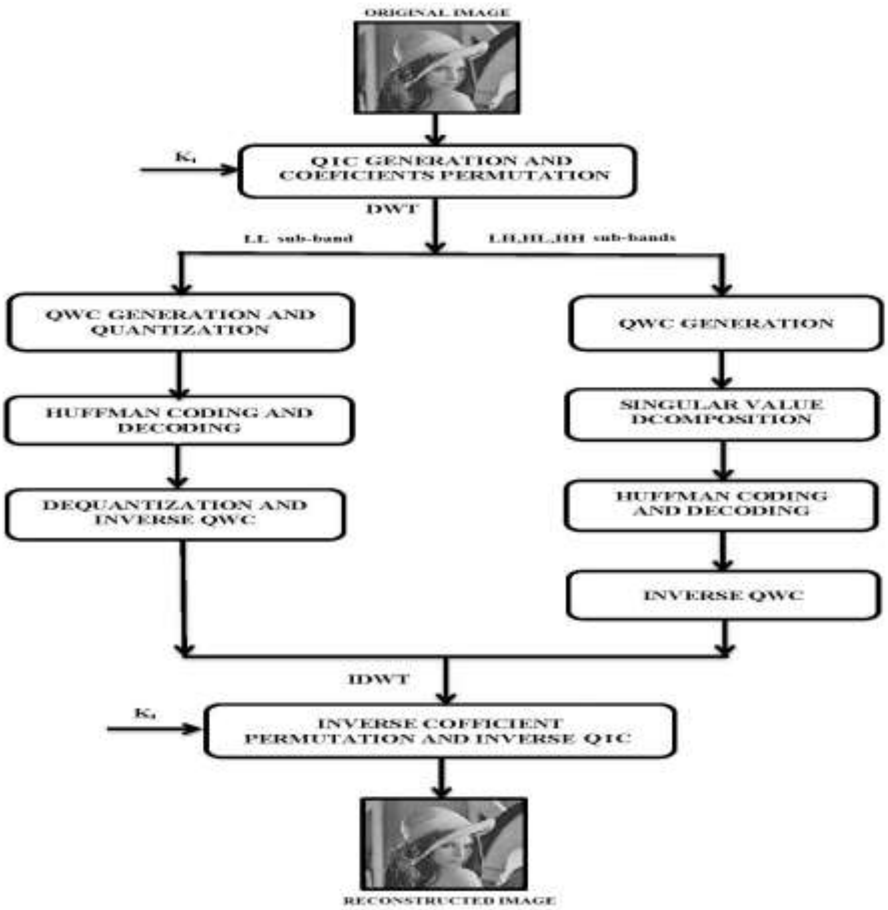

Figure (2) Proposed quantized & encryption then compression scheme

Step1: Initially we will find QI Coefficients for the input image.

Step2: Then encryption will be carried out by using pseudo random coefficient permutation method.

Step3: apply DWT for encrypted image, then will get LL, LH, HL and HH sub-bands.

Step4: For LL sub-band section we will apply QWC and quantization.

Step5: Then Huffman coding decoding and Dequantization & inverse QWC are applied.

Step6: For LH, HL, HH sub-bands we will find QW coefficients.

Step7: Then SVD and Huffman coding decoding and inverse QWC will be carried out.

Step8: LL sub-band section and LH, HL, HH sub-band section will be merged by inverse DWT.

Step9: We apply inverse QI coefficients and inverse pseudo random coefficients permutation.

Step10: Finally reconstructed image is obtained.

Required equations list: [8]

$QIC(i, j) = ((I(i, j)-IC_{min}).R)/(IC_{max}- IC_{min})$ (5)

$E(i, j) = mod[QWC(i, j)-S(i, j), 512]$ (6)

$QWC(i, j)=|((WC(I, j)-WC_{min}).R)/(WC_{max}- WC_{min})|,$

$1 \leq i \leq P/2, 1 \leq j \leq Q/2$ (7)

$Q(i, j) =|E(i, j)/\eta|, 1 \leq i \leq P/2, 1 \leq j \leq Q/2$ (8) $B=B_1+B_2+B_3+B_4$ (9) $CR=B/(P\times Q)$ (10)

Q'' (i, j) as: $Q''(i, j) = Q'(i, j)\times\eta$.

$A(i,j)=(Q'(i, j)/R).(WCmax - WCmin)+WCmin$ (11)

$E'(i, j) = mod[A(i, j)-S(i, j), 512]$ (12)

$I'(i, j) =(E'(i, j)/R).(IC max - IC min)+IC min)$ (13)

4. EXPERIMENTAL RESULTS

The proposed ETC technique is implemented using Matlab 9.4.0. To demonstrate various 8-bit gray scale images like Lena, Peppers each of size 512 ×512,are used which are shown in Figure(3)and Reconstructed images are shown in Figure(4).

4.1.1 Security analysis

The values of input image are encrypted using the pseudo random permutation is used to scramble the position of each of the detail wavelet coefficients independently. Hence, it would be difficult to any attacker to practically implement a successful brute force search on encrypted detail wavelet subbands. Therefore, the proposed scheme has attained a desired level of security

4.1.2 Compression performance evalution

The compression performance of proposed work for various images, CR and PSNR values are calculated with η=1and on different SVs. The proposed work is evaluated on different wavelets such as Biorthogonal, Haar. The results obtained on these wavelets with the variation of SVs are demonstrated in Tables I–II, it can be analyzed from average values shown in various tables that the proposed work gives better compression performance with improved image quality on Biorthogonal wavelet. For an instance, when Lena image is compressed using Biorthogonal wavelet on 256 SVs and η=1it gives 3.7144 CR with 44.7610dB PSNR while the CR values for other wavelets such as Symlets, Daubechies, Coiflets, Haar and Discrete Meyer wavelet are3.7174,3.714,3.7108,3.7124 and 3.7185 respectively while the corresponding PSNR values are 45.4934dB, 45.4366dB, 45.5626dB, 45.5292dB and 45.5087dB.

Figure(3) Original images

TABLE I

PSNR (DB) AND CR VARIOUS TEST IMAGES WITH VARYING SINGULAR VALUES ON BIORTHOGONAL (BIOR3.1) WAVELET.

SINGULAR VALUES	256		128		64		32		16	
	PSNR	CR	PSNR	CR	PSNR	CR	PSNR	CR	PSNR	CR
Lena	44.671	3.7144	31.1763	3.7131	27.2194	3.6697	26.5266	3.6074	26.3631	3.5458
Peppers	42.8998	3.7707	25.7576	3.7684	22.3036	3.7372	21.7012	3.6924	22.03	3.6495
Girl	44.6989	3.7285	36.3321	3.7346	32.5316	3.7047	31.9208	3.6607	32.2602	3.6089
Couple	43.0768	3.7211	29.9602	3.7178	25.8559	3.686	24.3602	3.638	23.8525	3.5921
Barbara	42.8276	3.6877	26.2814	3.6874	19.4147	3.6593	18.3028	3.6019	19.0613	3.5343
Boat	43.2044	3.7251	25.5841	3.705	21.9666	3.6764	21.204	3.6058	22.1529	3.5291
Baboon	40.5183	3.6501	28.2007	3.6436	24.6837	3.595	23.2061	3.525	22.4326	3.4464
Man	42.6831	3.7523	14.2492	3.7512	11.891	3.7198	11.9537	3.6747	12.4548	3.6326
Average	43.0724	3.7187	27.1927	3.7151	23.2333	3.681	22.3969	3.6257	22.5759	3.5673

TABLE II

PSNR (DB) AND CR VARIOUS TEST IMAGES WITH VARYING SINGULAR VALUES ON HAAR (HAAR) WAVELET.

SINGULAR VALUES	256		128		64		32		16	
	PSNR	CR	PSNR	CR	PSNR	CR	PSNR	CR	PSNR	CR
Lena	45.5292	3.7124	29.4322	3.7132	26.0479	3.6839	25.7669	3.635	26.7415	3.5872
Peppers	43.8741	3.7248	26.5318	3.7252	22.5342	3.7024	22.0475	3.6713	22.1539	3.6403
Girl	45.1921	3.7456	33.6053	3.746	30.0673	3.719	29.952	3.6747	30.3594	3.6287
Couple	44.217	3.6992	29.3154	3.6991	25.1571	3.6798	24.3589	3.6451	24.3256	3.6035
Barbara	41.2473	3.7018	25.8074	3.7007	20.0456	3.6705	19.0364	3.6138	19.7209	3.5418
Boat	44.4749	3.6615	25.8741	3.6598	22.3101	3.6325	21.0437	3.5867	21.2202	3.5364
Baboon	44.4175	3.7195	27.7242	3.7144	25.1509	3.6719	24.0118	3.6047	23.4898	3.5335
Man	40.8832	3.7473	14.0692	3.7479	11.7873	3.7245	11.6496	3.688	12.1284	3.6523
Average	44.1360	3.7092	28.3272	3.7083	24.4733	3.68	23.7453	3.633	24.0016	3.5816

Figure (4) Reconstructed images

5. CONCLUSIONS

This paper proposed a simplest effective Encryption-then-Compression technique using SVD and Huffman coding. At the sender end, content owner decomposed the original image into a wavelet decomposition using DWT. At the sender side the input image is quantized and encrypted using pseudo random permutation, which makes the proposed scheme secure against any brute force search. The encrypted LL sub-band is compressed by quantization and Huffman coding, the encrypted LH, HL, HH sub-bands are compressed using SVD and Huffman coding technique. The receiver can perform the decompression, decryption and inverse of DWT and inverse quantization to get the reconstructed image.

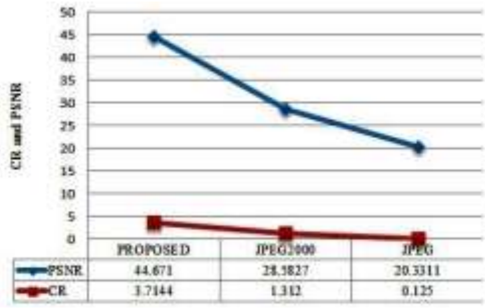

Figure (5) Graph between CR&PSNR for different compression schemes with comparison table.

The performance analysis of proposed work is evaluated by comparing the unencrypted images. It is evident from the quantitative and visual results that the proposed scheme over JPEG&JPEG2000 on compression of encrypted image. Proposed scheme has an advantage of using SVD due to which we have obtained good compression performance while retaining the desirable features of the reconstructed.

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