An Efficient Approach Implementation to Image Compression and Encryption

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ABSTRACT

The intent of image compression is to cut down the redundancy of the image and to store or transmit data in an effective form. Also, the encryption is considered one of the important fields in the computer industry which is specialized in the Information Security transmission. Encryption, the process which helps in such secure transmission, prevents hackers from accessing the information. Decryption assists to recover the original information. This paper contains an approach to applying image compression with encryption using the secret key. The major goal of such method is to reduce the RGB image quantity as much as possible using DCT transform, and quantized the resulted image using Rounded to nearest integer, Default Quantization Tables (chrominance , Luminance), Simple Quantization Tables, and default table. after quantization process the run-length encoding algorithm RLE is used. i.e. the DCT transform applies for each band of RGB image and three methods of quantization applied to the resulted coefficients then the RLE compression method used. However alone compression is not sufficient as it has an open access, anybody can access it. So if it is desired that it can be accessible only by authorized person it should be encrypted as well. In the encryption process divided the resulted RLE matrix for each band of the RGB image into the odd and even position and encrypted them using a key generator, which consist of three registers each one of 32 bit length and connected with each other using strong non- linear function, To increase the security of this system, the encryption process did not sequentially . The receiver decrypts the encryption file then apply the RLE decoding and the dequantization process. Finally, the inverse of the DCT algorithm made. To assess our system number of measurements used such as histogram, correlation, and compression ratio C.R between the compression and retrieved images for each method of the quantization to show the strength of this system. This system implemented using visual basic 6.0.

Keywords: DCT, Quantization, RLE, Encryption ,Decryption

1. Introduction

Encryption is the procedure of encoding statement or data in a different ways to be known only by the an authorized person to understand it. Into an encryption system, the message or information which known as plain text, can be encrypted using an encryption algorithm, converting it into a scribbled cipher text. This process is made using the encryption key. The unauthorized person that not be capable to determine everything about the original message but only observe the cipher text. Using decryption algorithms an authoritative party, decode the cipher text, which require a secret decryption key[1].

Many methods and techniques for secure communication provided by the cryptography[2].To satisfy the demand for safe image transmission through the wireless networks and Internet, image encryption have been increasingly studied. With the vast increase of computer link systems and the most recent advances in digital technical innovation,, a massive quantity of digital information, where a significant portion of this information is sometimes secret or non-public is being exchanged over diverse types of networks.

When the image is large the classic image encryption algorithm like a data encryption standard (DES), has the weak spot of low-level performance. To provide the necessary security, different security methods have been used [3]. Due to the fast growth of the internet in the digital world today, therefore the security of digital images has become more and more significant.To improve the security of these images several image encryption techniques have been discovered[4].

The main goal of the image encryption methods is to change an image to another one that is difficult to recognize [3].In addition to that, to retrieves the original image from the encrypted one image decryption has been used.

In the field of multimedia computer, the data compression [5] and image compression [6] acting a very important part in the communication. The most popular method for compression is discrete cosine transform (DCT) because it has an optimal performance and capability to be implemented at a reasonable cost. DCT have been used in several of commercially compression algorithms, such as the JPEG standard [7] for still images and the MPEG standard [8] for video images.

Because the adjacent pixels of the most images are greatly associated and include a lot of redundant information, therefore a compression algorithm have been used to a reduce this redundant. The most important methods of image compression are Predictive Coding such as DPCM (Differential Pulse Code Modulation), Orthogonal Transform such as Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT).Also selection of the proper transform is one of the essential tasks in image compression.

In this paper, we used the image compression transform Discrete Cosine Transform(DCT) with the encryption processes to reduce the size of the image and to increase the security of transmission.

2. Discrete Cosine Transform

One of the most important compression method having perfect performance with the highest energy compared with any other transform is a discrete cosine transform (DCT). The main benefit of this transform is to delete redundancy between neighboring pixels and this leads to non-interrelated component scan be coded independently. The 2-D DCT can be obtained from two 1-D DCTs. The 2-D DCT is given by Equation (1)

$$C(u,v)=\alpha(u)\alpha(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\cdot Cos\left[\frac{\Pi(2x+1)u}{2N}\right]\cdot Cos\left[\frac{\Pi(2y+1)v}{2N}\right] \quad (1)$$

For u,v= 0,1,2,...,N −1 . The inverse transform is defined by Equation (2)

$$f(x,y)=\sum_{u=0}^{N-1}\sum_{v=0}^{N-1}\alpha(u)\alpha(v)\cdot C(u,v)\cdot Cos\left[\frac{\Pi(2x+1)u}{2N}\right]\cdot Cos\left[\frac{\Pi(2y+1)v}{2N}\right] \quad (2)$$

For x, y= 0, 1, 2,..., N −1. By multiplying the horizontally oriented 1-D basis functions with a vertically oriented set of the same functions the 2-D basis functions can be obtained. The process started by the pixels of the image is partitioned up into 8x8 windows. (where each color is processed separately. The results of this process is to transform a spatial image form into a frequency form: the average value in the block manifested by " DC", though ("AC") represent the strength via the width or height of the block, which mean the strength of a cosine wave alternating from maximum to minimum at neighboring pixels [10].

3. Quantization

The term of quantization refer to the method of reducing the number of bits needed to represent quantity for value, which satisfy the balance between the image quality and degree of quantization .large image distortion can produce from a large quantization and the lower compression ratio constructing from the finer quantization.

Therefore, we need to build more efficient quantize DCT coefficient. The high frequencies play a less important role than low frequencies, therefore, the human eye's light natural to high frequency[11].The quantization is followed the process of calculation for DCT coefficients c (u, v), where information is lost [12]. The quantization matrix is an 8*8 matrix of step sizes called quantum and then rounds to the nearest integer.DCT coefficients divided by the corresponding quantum of quantize table . Large quantum's drive small coefficient down to zero [11].the kind of quantum matrix which are used by compression algorithm is:

3.1 Default Quantization Tables

There are tables One them, for luminance (grayscale), and the others for chrominance components, which are outcome for several tests performed by the JPEG standard and are produced here as table(1) shown in table (2) for luminance chrominance respectively.

Table (1) Default luminance Quantization Table

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	51	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	10 9	10 3	77
24	35	55	64	81	10 4	13	92
42	64	78	87	10 3	12 1	12 0	10 1
72	92	95	98	11 2	10 0	10 3	99

Table (2) Default chrominance Quantization Table

17	18	24	47	99	99	99	99
18	21	26	66	99	99	99	99
24	26	56	99	99	99	99	99
47	66	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99

This is a table calculated, based on one operate parameter R supplied by the user. A straightforward expression like as Qij = 1+(i+j)*R makes certain that QCs begin small at the top left corner and get larger when it comes to the bottom right corner [12] .in this study used R=2 is used , then the table(3) used is*:*

It can see the quantization chrominance system in the table typically increase as we proceed from the top left arrive at the bottom part of a right corner.

3.2 A simple quantization table Q

Table (3) Simple quantization table

1	2	4	8	16	32	64	128
2	4	4	8	16	32	64	128
4	4	8	16	32	64	128	128
8	8	16	32	64	128	128	256
16	16	32	64	128	128	256	256
32	32	64	128	128	256	256	256
64	64	128	128	256	256	256	256
128	128	128	256	256	256	256	256

Also used rounded to nearest integer, where the result is rounded to the nearest integer.

4. Run length encoding (RLE)

The run- length encoding algorithm is employed to 64 quantities of one-dimensional, to reduce the repetition of the coefficient value which are similar especially zero coefficients that produced by DCT transform and Quantization by counting the number of repetition of coefficients of the same value which represent the counter followed by coefficient value such as 88 88 88 88 88 88 stored as (6 ,88), whereas go through the compressed file by the inverse run length coding algorithm , and read byte after byte ,the first byte represent count, if count not equal to 64 then read data and decompress repetition.

5. Performance Measures

To approximate the distinction between the original and the decompression image, and to assess the overall performance of the image compression. Two typical measurements are used, the Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR), which are described in (3) and (4), respectively. f(j,k) and C(j,k) represent the pixel value of the original and decompression image accordingly. Most image decompression systems are intended to minimize the MSE and maximize the PSNR.

$$e_{RMS} = \sqrt{\frac{1}{N^2}\sum_{j=0}^{N-1}\sum_{k=0}^{N-1}[C(j,k)-f(j,k)]^2} \quad (3)$$

$$PSNE = 10\log_{10} \frac{(L-1)^2}{\frac{1}{(N\times M)} \times \sum_{j=0}^{N-1}\sum_{k=0}^{M-1}[C(j,k)-I(j,k)]^2} \quad (4)$$

CR= Uncompressed file size /compressed file size [13].

Another measurements are used for evaluation the strength of this system such as[14][15] :

$$\text{Average Difference (AD)}=\sum_{j=1}^{M}\sum_{k=1}^{N}(f(j,k)-C(j,k))/MN \quad (5)$$

$$\text{Structural Content (SC)}=\sum_{j=1}^{M}\sum_{k=1}^{N}(f(j,k)^2 / \sum_{j=1}^{M}\sum_{k=1}^{N}(C(j,k)^2 \quad (6)$$

$$\text{Maximum Difference (MD)}=\text{Max}(\|f(j,k)-C(j,k)| \quad (7)$$

$$\text{Normalized Absolute Error (NAE)}=\sum_{j=2}^{M}\sum_{k=2}^{N}|f(j,k)-C(j,k)| / \sum_{j=2}^{M}\sum_{k=2}^{N}|f(j,k)| \quad (8)$$

6. Encryption key generator

In the form of Synchronous stream cipher with 3 LFSR's. A non-linear Boolean function F brings together the three registers to supply the generator end result Boolean Function F
F(x1,x2,x3) = (x1 AND x2) XOR (NOT x1 AND x3) as shown in figure (1):

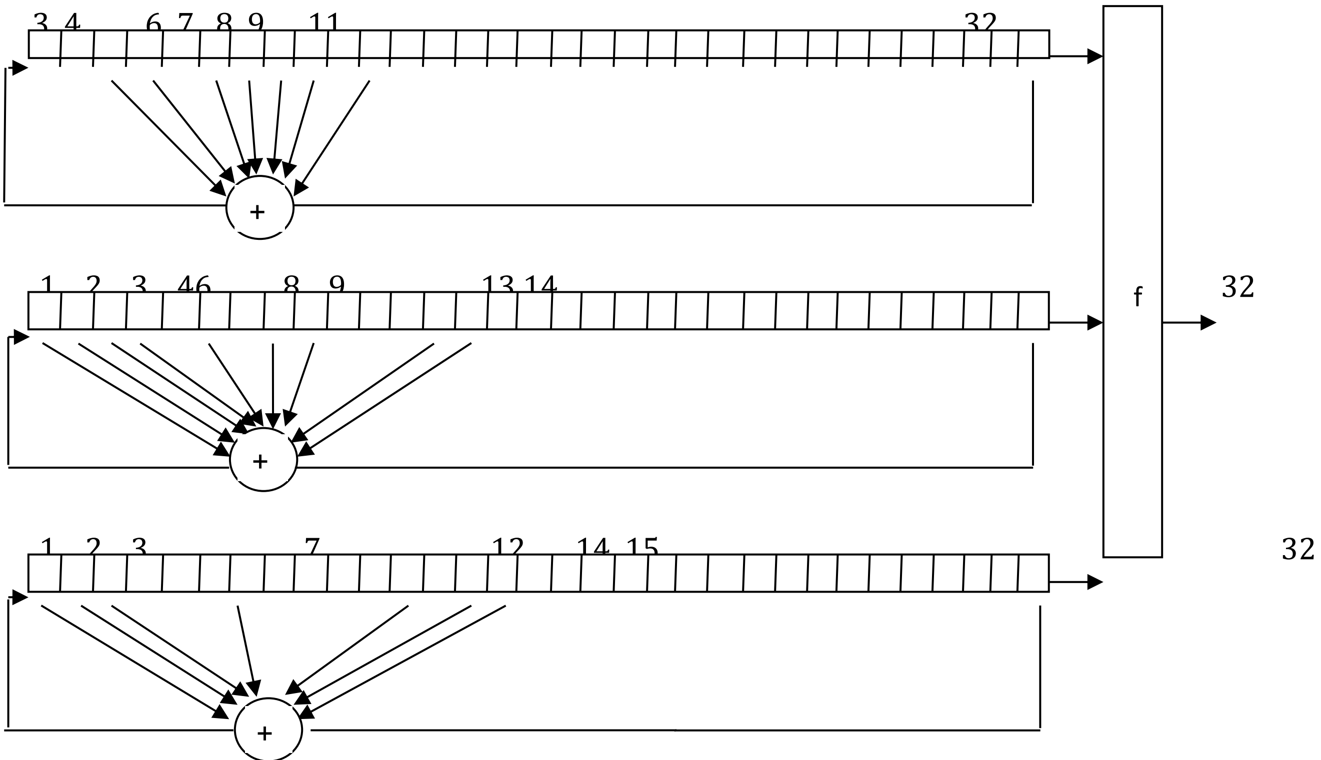


Figure (1) the encryption key generator

LFSR1 primitive polynomial *:* $1+x^{2}+x^{3}+x^{6}+x^{7}+x^{8}+x^{9}+x^{11}+x^{32}$
LFSR2 primitive polynomial *:* $1+x+x^{2}+x^{3}+x^{4}+x^{6}+x^{8}+x^{9}+x^{13}+x^{14}+x^{32}$
LFSR3 primitive polynomial *:* $1+x+x^{2}+x^{3}+x^{7}+x^{12}+x^{14}+x^{15}+x^{32}$

7. Architecture of the proposed system

This architecture involves a sub-block of compression and encryption, which contain discrete cosine transform (DCT), along with methods of quantization, and RLE coding blocks. In the encryption block where each band of the RLE divided into the odd and even position and encrypted randomly using the above encryption key. In the other side the receiver decrypted the received file for each band return the original position, perform de-quantization process. Finally apply the inverse of the DCT algorithm as shown in figure (2).

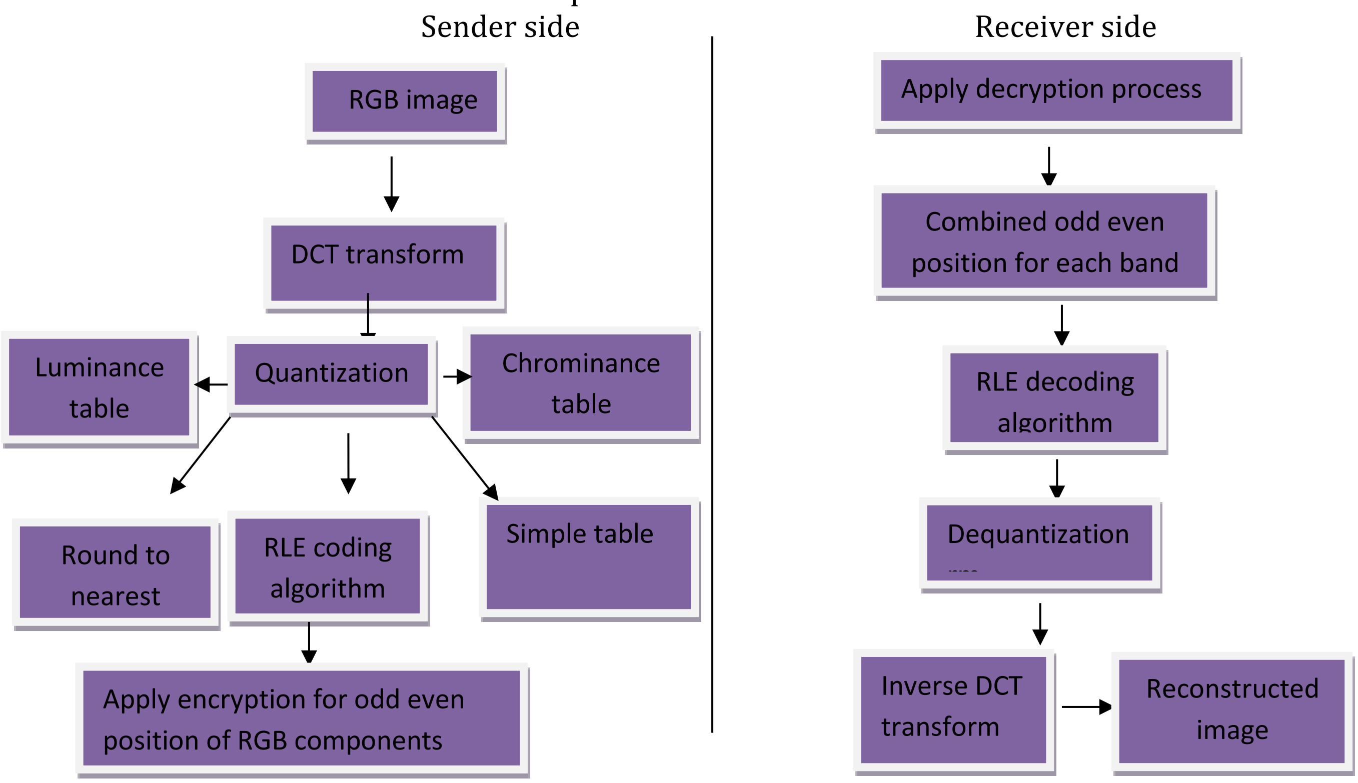
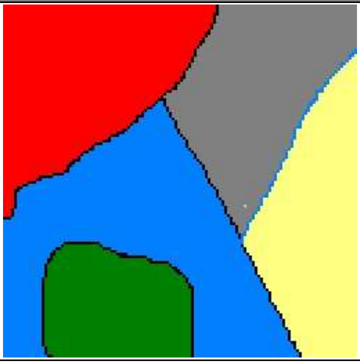
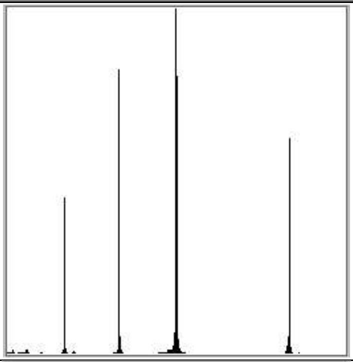
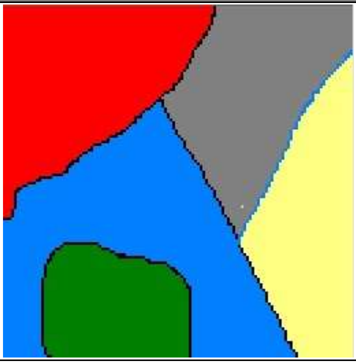
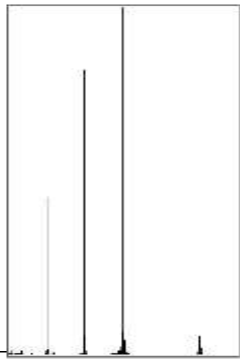
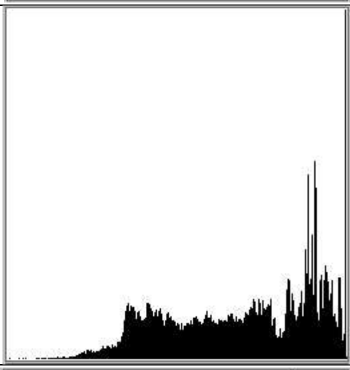
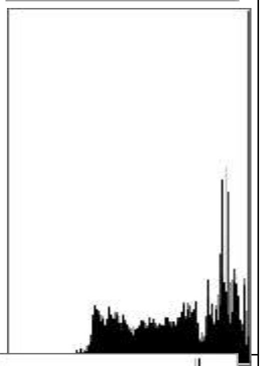
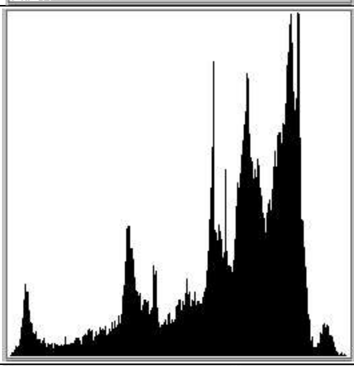
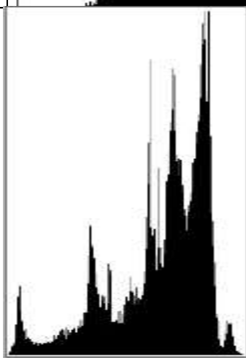
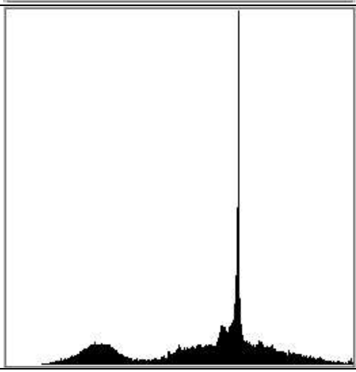
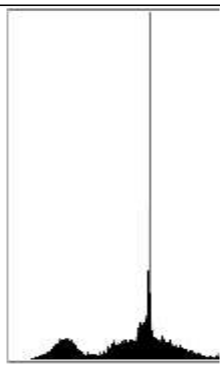


Figure (2) the diagram of the suggested system

8. Results and implementation of suggested system

The results presented the implementation of five images for each band and method of quantization. In tables (4,5) showed the histogram between the original and decompressed images ,table (6) explain the compression ratio, while tables (7,8,9,10,11) studied the effect of using the performance measurements for each method of quantization for the above images, whereas table (12) calculated the correlation between the original and decompressed images as shown below

Table4: source image , reconstructed image after apply method 2 and their histogram

Source (Case)Image	Histogram of Source Image	Reconstruction image	Histogram of Reconstruction Image
			
			
			
			

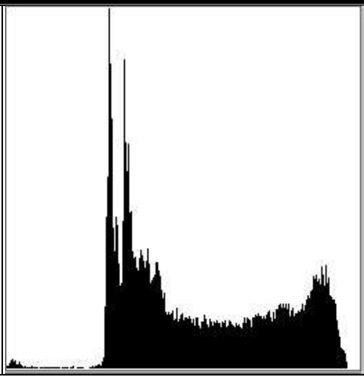
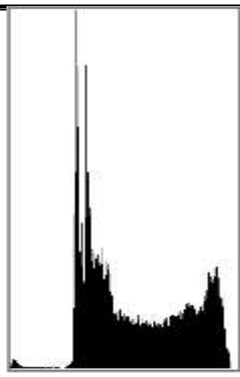
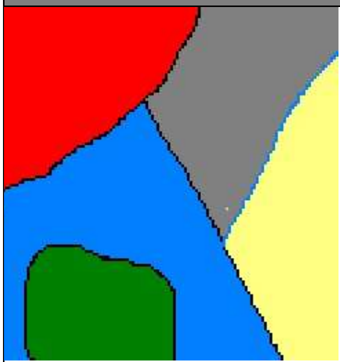
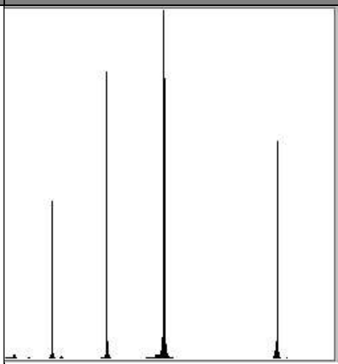
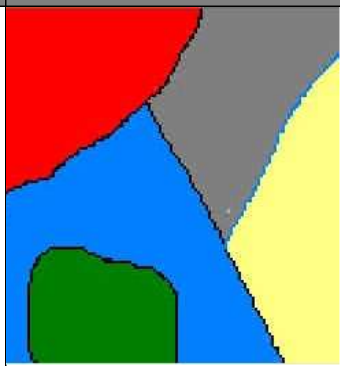
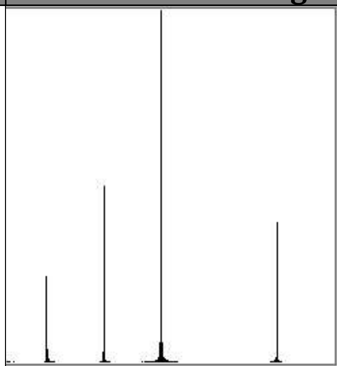
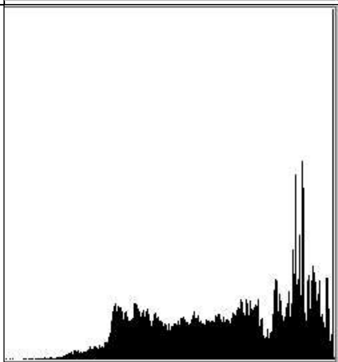
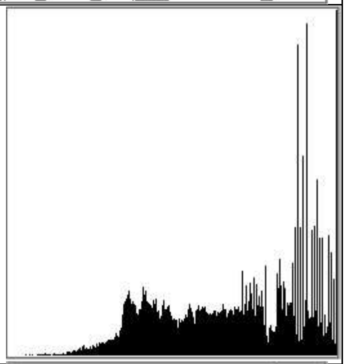
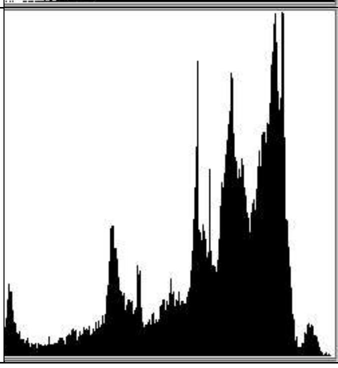
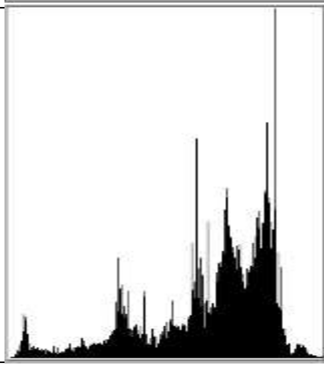
			

Table 5: source image , reconstruction image after apply method 2 and their histogram

Source Image	Histogram of Source Image	Reconstruction image	Histogram of Reconstruction Image
			
			
			

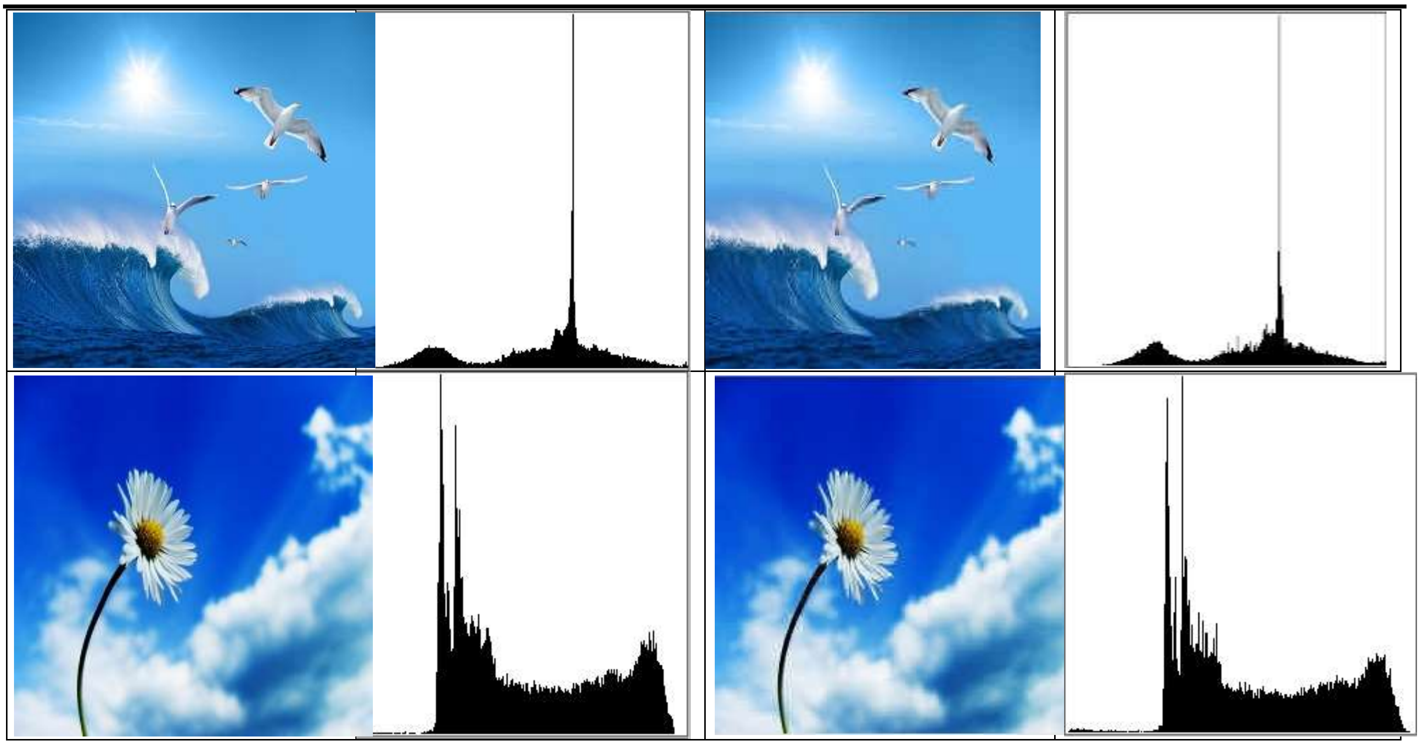


Table 6: compression ratio in five methods for five images

		Method 1	Method 2	Method 3	Method 4	Method 5
case 1	R	68%	90%	87%	81%	85%
	G	71%	90%	88%	83%	86%
	B	65%	89%	86%	80%	84%
case 2	R	25%	85%	80%	67%	73%
	G	28%	85%	80%	68%	73%
	B	23%	85%	80%	67%	73%
case 3	R	12%	85%	78%	63%	69%
	G	18%	85%	78%	63%	69%
	B	12%	85%	78%	63%	69%
case 4	R	16%	84%	75%	54%	68%
	G	19%	83%	74%	54%	69%
	B	14%	84%	74%	54%	68%
case 5	R	14%	84%	78%	68%	72%
	G	18%	84%	79%	69%	72%
	B	10%	87%	81%	71%	73%

Table 7: Image quality metrics values comparison for case 1

Method		MSE	PNSR	AD	SC	MD	NAE
1	R	0.0243	64.2707	-0.0051	1	2	0.0002
	G	0.0228	64.5434	0.004	1	1	0.0002
	B	0.0257	64.0270	0.0009	1.001	2	0.0002

2	R	26.6555	33.8729	-0.2208	1.002	87	0.0147
	G	28.2466	33.6221	0.3585	1.0069	71	0.0155
	B	29.7379	33.3977	0.0683	1.0034	76	0.167
3	R	13.4871	36.8316	-0.0578	1.004	50	0.0101
	G	13.5145	36.8228	0.0599	1.0046	52	0.0099
	B	14.9846	36.3743	0.2945	1.0072	50	0.0133
4	R	2.1088	44.8904	-0.1127	1.004	21	0.0041
	G	1.822	45.3841	-0.0318	1.004	18	0.0037
	B	2.2626	44.5846	-0.0381	1.0008	18	0.0044
5	R	16.6162	35.9355	-0.1872	1.0019	60	0.0091
	G	17.8177	35.6323	-0.504	1.0021	93	0.0094
	B	19.5963	35.2090	-0.0487	1.0029	92	0.0106

Table 8: Image quality metrics values comparison for case 2

Method		MSE	PNSR	AD	SC	MD	NAE
1	R	0.0626	60.1635	0.0048	1	2	0.0003
	G	0.0619	60.2146	0.0054	1.0001	1	0.0003
	B	0.0631	60.1308	0.0029	1	1	0.0004
2	R	35.5267	32.6253	0.024	1.0006	117	0.0153
	G	35.2079	32.6644	0.0427	1.0008	105	0.0151
	B	34.9983	32.6903	-0.0213	1.0006	109	0.0184
3	R	18.2499	35.5182	0.0179	1.0004	68	0.0112
	G	18.482	35.4633	0.0103	1.0004	73	0.0112
	B	18.4798	35.4538	-0.0396	1.0002	76	0.0137
4	R	3.8496	42.2766	0.0209	1.0002	24	0.0059
	G	3.7926	42.3414	0.0247	1.0002	19	0.0058
	B	3.8636	42.2609	-0.0056	1.0001	17	0.0072
5	R	19.9249	35.1368	0.0297	1.0007	78	0.0098
	G	20.112	35.0962	0.0289	1.0007	77	0.0097
	B	19.7756	35.1695	-0.0271	1.0005	78	0.0119

Table 9: Image quality metrics values comparison for case 3

Method		MSE	PNSR	AD	SC	MD	NAE
1	R	0.0743	59.423	0.0043	1	1	0.0004
	G	0.072	59.558	0.0035	1	1	0.0005
	B	0.0713	59.5996	0.0036	1	2	0.0005
2	R	23.6521	34.3921	0.0424	1.0007	72	0.0148
	G	24.3518	34.2655	-0.0489	1	74	0.0187
	B	24.5322	34.3234	0.0087	1.0009	70	0.0188
3	R	10.7547	37.8148	00.238	1.0004	60	0.0108
	G	10.9984	37.7175	-0.0225	1	56	0.0135
	B	10.1244	37.6680	0.0162	1.0007	61	0.0137

4	R	3.3854	42.8347	0.0219	1.0002	16	0.0064
	G	3.4412	42.7637	-0.0008	1	16	0.0081
	B	3.4913	42.7009	-0.0011	1	16	0.0082
5	R	8.8803	38.6465	0.0333	1.0005	53	0.0086
	G	9.1029	38.539	-0.0158	1.0002	55	0.0108
	B	9.2145	38.4860	-0.0155	1.0003	53	0.011

Table 10: Image quality metrics values comparison for case 4

Method		MSE	PNSR	AD	SC	MD	NAE
1	R	0.0688	59.7548	0.0014	1.0001	1	0.0008
	G	0.0676	59.8325	0.0052	1.0001	1	0.0004
	B	0.0691	59.7336	0.0059	1.0001	2	0.0003
2	R	46.1747	31.4868	0.0638	1.0037	81	0.0438
	G	50.2184	31.1222	-0.0117	1.0008	99	0.0247
	B	50.1212	31.1305	0.054	1.0013	101	0.0189
3	R	27.2532	33.7766	-0.1093	1.0006	76	0.0339
	G	29.4394	33.4415	0.094	1.0017	65	0.0197
	B	29.0316	35.5020	0.0857	1.0012	63	0.0147
4	R	6.6418	39.9079	-0.1351	0.9996	20	0.0184
	G	7.1002	39.6181	0.0089	0.9998	24	0.0104
	B	7.0526	39.6473	0.0193	1	20	0.0078
5	R	27.081	33.8042	-0.0778	1.0017	68	0.0305
	G	29.3244	33.4585	0.0056	1.0008	71	0.0176
	B	28.6553	33.5587	0.0212	1.0006	66	0.0131

Table 11: Image quality metrics values comparison for case 5

Method		MSE	PNSR	AD	SC	MD	NAE
1	R	0.0717	59.5774	-0.0037	1	1	0.0009
	G	0.0737	59.4561	0.0042	1.0001	1	0.0006
	B	0.0735	59.4696	0.0034	1	1	0.0003
2	R	23.4204	33.5945	-0.0521	0.9999	91	0.0333
	G	27.0249	33.1832	0.0001	1.0006	93	0.0195
	B	24.7583	34.1936	-0.0364	1.0002	66	0.0116
3	R	13.441	36.8465	-0.0218	0.9994	68	0.0235
	G	13.401	36.9448	-0.0385	1	70	0.014
	B	12.3827	36.2026	-0.0196	1.0001	60	0.0086
4	R	2.7215	43.7827	-0.0252	0.9999	17	0.0121
	G	2.6301	43.931	0.0002	1	19	0.07
	B	2.6655	43.8730	0.0034	1.0001	20	0.0045
5	R	13.9523	36.6843	-0.0727	1.0005	74	0.0188
	G	13.8566	36.7142	-0.0212	1.0005	79	0.0107
	B	13.0914	36.9609	-0.0114	1.0003	79	0.0068

In the above tables(7,8,9,10,11) for each method of quantization and for each band for RGB image, the measurements have been calculated such as PSNR, MSE,AD,SC,MD and NAE respectively.

Table 12: correlation between source image and image after decompression in five methods for five images

		Method 1	Method 2	Method 3	Method 4	Method 5
case 1	R	1	0.999	0.9995	0.999	0.9994
	G	1	0.9978	0.999	0.999	0.9986
	B	1	0.9985	0.9993	0.999	0.999
case 2	R	1	0.9944	0.9971	0.9994	0.9969
	G	1	0.9947	0.9972	0.9994	0.997
	B	1	0.9972	0.9985	0.9997	0.9984
case 3	R	1	0.9962	0.9983	0.9995	0.9986
	G	1	0.9948	0.9976	0.9993	0.9987
	B	1	0.9965	0.9984	0.9993	0.99
case 4	R	1	0.9928	0.9957	0.999	0.9958
	G	1	0.9908	0.9946	0.9987	0.9947
	B	1	0.9885	0.9933	0.9984	0.9934
case 5	R	1	0.9979	0.999	0.9998	0.999
	G	1	0.9973	0.9987	0.9997	0.9986
	B	1	0.9865	0.9933	0.9986	0.9929

9. Conclusions

1- The best way of fast and secure transmission is by using compression and encryption of multimedia data like images when using encryption with compression process adding security to the RLE coefficients which transmission .

2- he addition of encryption to the compression process increases the security transmission. When the unauthorized person attempt to obtain the information he(she) must obtain the key(which is strength designing) and then performed the decompression process.

3- For each odd and even position of RGB vector using non-sequential key increase the security process ,because for each band of RGB images dividing to the odd and even position and using the key stream non-sequentially which also increase the security

4- The length of the key is very long to avoid the repetition of the ciphering process. Each LFSR has 32 bits length the resulting sequence has 232 length to be more than the compressed data avoiding the repetition.

5- In the quantization stage used five methods each one of the given different results, where the rounded to nearest integer give the high correlation but small compression ratio while the correlation decrease but the compression ratio increase between the original and reconstructed image in default chrominance quantization table.

6- When the correlation value close to 1 this means there is no different between the original and reconstructed image while the zero value means there is no correlation between them. In our results and in all methods of quantization showing the high correlation between the original and reconstructed image for all images.

7-The increasing of R-value in the simple table quantization cause the increasing the compression ratio and decreasing the correlation value. This value experimented for different values such as R=3,4,5,..

8- If the image has a higher correlation between pixels the compression ratio increase i.e.

there is a relation between the correlation of the images and the compression ratio.

9-The performance evaluation factors such as PSNR ratio, MSE, AD, SC, MD, `NAE and correlation for compression showing a good results ,which mean the image has a high quality and less difference between the original and reconstructed images.

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