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Image Compressionusing Hybrid Method

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Abstract

The large growth usage of internet rises the need to transfer and save multimedia files, therefore appeared need for compression methods that give better compression results.This paper presents a proposedlossy image compression technique using singular value decomposition (SVD) and embedded zero tree wavelet (EZW) to compress color and gray images.Singular value decomposition based compression reduces the psychovisual redundancies find in the image through rank reduction method and embedded zero tree wavelet gives higher compression ratio (CR). The experimental results of the proposed image compression technique are shown and also compared with other methods. From the results of the comparison, the proposed image compression technique is better than other methods.

Keywords—EZW Compression; SVD compression .

ضغط الصور باستخدام طريقة هجينة

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الخلاصة

إن النمو الكبير في استخدام الإنترنت يزيد من الحاجة إلى نقل ملفات الوسائط المتعددة وحفظها ، وبالتالي ظهرت الحاجة الى طرق ضغط تعطي نتائج افضل . تعرض هذه الورقة تقنية مقترحه لضغط الصور بفقدان باستخدام تحليل القيمة المفردةوEZWلضغط الصور الملونة والصور الرمادية .الضغط باستخدام تحليل القيمة المفردة يقلل من التكرارات التي تتحسسها العين البشرية الموجودة في الصورة من خلال طريقة خفض الرتبة و EZW تعطي نسبة ضغط أعلى .يتم عرض النتائج التجريبية لتقنية ضغط الصورة المقترحة وكذلك مقارنتها بالطرق الأخرى .من نتائج المقارنة ، تقنية ضغط الصور المقترحة أفضل من الطرق الأخرى.

كلمات البحث :الضغط باستخدام تحلل القيمة المفردة ,الضغط باستخدامEZW.

1- Introduction

The amount of data correlated with visual information is so large that its storage would demand enormous storage capacity. When carried such types of data from one location to another through networking then they take up more time for transmission[1].

Demand for telecommunications of multimedia data through the network and accessing the multimedia data through Internet is increasing explosively[2] .

The image has become the most important information carrier in people's life or the biggest media containing information. Therefore storing and transferring images continues to increase. A large amount of data is in image , mostly with redundant information that takes huge storage space and reduce transmission bandwidth. Thus we need to compressed it [3].

Image compression includesreducing the typicallyhugeamount of data wanted to represent an image. Thisachieved by removing data that are visuallyunnecessary.The basic idea of image compression is to remove the redundancy of datapresented within an image to reduce its size without affecting the essential information[4].

The compression algorithmsdividedintotwo classes, Lossless and Lossy compression algorithms.In lossless compression methods, the reconstructed image, after compressioniscompletelysimilar to the original image .In the second type the reconstructed image does not match the original image completely and containsdegradation relative to the original [2].

In thisresearchwork, a new lossy compression technique whichemployssingular value decomposition (SVD) and embeddedzerotreewavelet (EZW) ispresented. In the proposed compression technique, the input image isfirstlycompressed by SVD and the resultthencompressed by EZW . The proposed technique has been tested on severalwell-known images (standard test image) such as, Lena, Peppers, Boat, and Cameraman. The results of this technique have been comparedwiththose of EZW and SVD techniques. The experimentalresultsbased on compression ratio(CR) show that the proposed technique overcomes the aforementioned techniques. The SVD and EZW image compression techniques are discussed in the next section.

2- Relatedwork

Manyresearchers uses SVD or EZW method in theirworks , some of publishedworks are the following Janaki. R and Dr.Tamilarasi.A ,(2011), proposed a technique for image compression which uses the Wavelet-based image Coding by usingembeddedzero-treewavelet encoder. Theyconcludedthis techniquegiveshigher compression ratio and better PSNR[5].

MeenakshiChaudhary and AnupmaDhamija ,(2013), proposedhybridwavelet (combination of MFHWT and Symletwavelet) by applyingSingular value decompositionmethod.Performance of proposedmethod has been analyzed and present a number of practicalexperimentswithvariousmedical images. Theyconcludedthatthesemethodsgivecompletelysatisfyingresults in bothvisual and numerical aspects. In addition, they are very effective and easy to implement[6].

Raghavendra .M.J et al, (2015), proposedhybrid image compression which uses DiscreteCosineTransform(DCT), Singular Value Decomposition(SVD) and RunlengthEncoding(RLE). They show thatusing DCT-SVD-RLE methodgives good compression ratio (CR) by loosing (PSNR) around 2dB [7].

RanjeetKumar,et al ,(2016),proposed an algorithmbased on singular value decomposition (SVD), and embeddedzerotreewavelet (EZW) techniques for electrocardiogram (ECG) signal compression. The proposedmethodusing (SVD) and then (EZW) for final compression. It foundthatproposedmethodwas efficient and flexible withdifferent types of ECG signal for compression, and controlsquality of reconstruction. the proposedmethodplay a bigrole to save the memoryspace of health data centres as well as save the bandwidth in telemedicinebasedhealthcaresystems[8].

Nijjar, H. S. and Singh, C., (2016), present a method of combinationalcodingusingembedded zero tree wavelet, huffman and arithmetic technique. The proposedmethod of Joint coding provides improved compression ratio as compared with huffman coding alone[9].

AshpinPabi D.J. et al ,(2017), proposedsingular value decomposition (SVD) and butterflyparticleswarmoptimization (BPSO). Application of the concept of BPSO towardssingular value decompositionreduces the encoding time and improves the transmission speed. The resultsshowedthat the methodachieves good PSNR with the minimum encoding time[10].

3.Theortical Background

This section discusses background of the study, particularly Singular Value Decomposition(SVD), Discrete Wavelet transform (DWT) andEmbedded Zero tree Wavelet(EZW).

3.1Singular Value Decomposition (SVD)

(SVD) is an approach of advanced linear algebra. SVD is a linear matrix transformation used for compressing images which decompose a digital image matrix into product of three matrices. Two of these matrices are orthogonal matrices and third is diagonal matrix. In diagonal matrix there are diagonal elements which are the singular values of image matrix.The singular value decomposition is defined as a factorization of a real or complex, square or non-square matrix. Consider a matrix A with

m rows, n columns and rank r.Then A can be factorized into three matrices[11].

$A = USV^T$ 1

$$A = \begin{bmatrix} u_1 & u_2 & \cdots & u_m \end{bmatrix} \begin{bmatrix} s_1 & 0 & \cdots & 0 \\ 0 & s_2 & \cdots & \vdots \\ \vdots & 0 & \ddots & 0 \\ 0 & \cdots & 0 & s_n \end{bmatrix} \begin{bmatrix} v_1^T \\ v_2^T \\ \vdots \\ v_n^T \end{bmatrix}$$

..... 2

$\overline{i=1}$

Where,

A is image matrix,

U is m × m orthogonal matrix,

S is m× n matrix with singular values on the diagonal,

V is n× n orthogonal matrix,

U_i, v_i are the corresponding eigenvectors of AA^T and A^TA.

The m columns of U and n columns of V are called the left-singular and right-singular vectors of A respectively.

The singular values of S are arranged as S1> S2 >…> 0 where the largest singular values precede the smallest and the last values of S are approximately equal to zero, they can be removed[12, 13].

Because the diagonal matrix has sorted singular values in descending order by using the physcovisual concept, the visual quality of the image will not be decreased by ignoring small singular value . The image can be reconstructed by using little amounts of singular values. This characteristic makes SVD suitable for compression, because the singular values that neglected do not recovered after rebuilding of the image [14].

3.2Discrete wavelet transform(DWT)

Discrete wavelet transform (DWT) represents the data into a set of low pass (approximate) and high pass (detail) filters. The input data is crossed through set of both low pass and high pass filter in two directions, both rows and columns. The outputs are then down sampled by (2) in each direction. The total process is clarify in Figure (1).

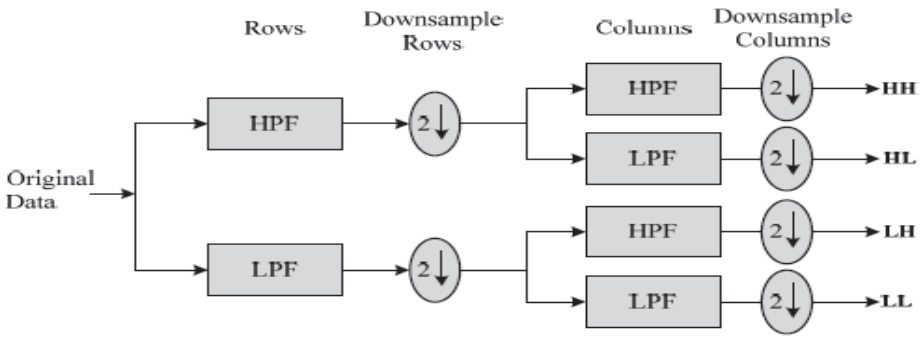


Figure (1):Block diagram of 1-D forward DWT[15]

In (DWT) reconstruction, input data can be done in multiple resolutions by decomposing the LL coefficient in to different levels as shown in Figure 2.

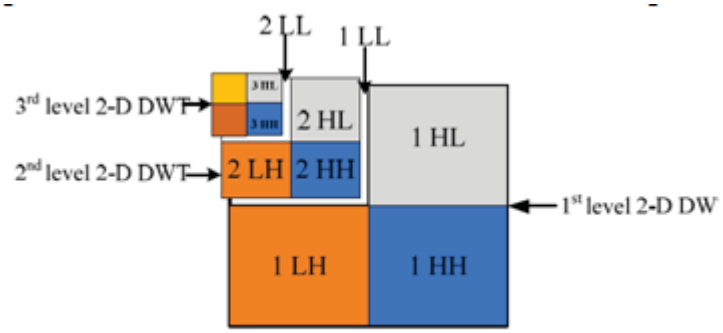


Figure (2) : 2-D DWT three level [15]

3.3Embedded zerotreewavelet(EZW)

The embedded zero tree wavelet (EZW) coder is coding and a quantization strategy that incorporates some characteristics of the wavelet decomposition. It was introduced by Shapiro in 1993. The EZW algorithm used distinguishing feature is that there are wavelet coefficients in various sub-bands that represent the same spatial location in the image[16].

The image is first decomposed by using DWT.This happens because real world images include mostly low frequency information and high frequency information[17].

The encoder module counts a initial threshold for coding given by

$T_0=2^{\wedge(\log 2Xmax)}$……3

Where ,

T_0 the initial threshold,

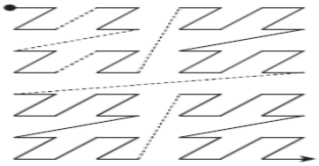
X_{max} large wavelet coefficient.

The encoding process is doneusing two passes namely dominant pass and subordinate pass. The dominant pass scans the coefficient by using Morton scan. Figure (3) shows Morton scan.After

coefficient scanning, compare it to the threshold and gave each coefficient a symbol. Basically there are four symbols for coding, they are [18]:

positive significant (P) , negative significant (N): if the absolute value of the wavelet coefficient in the sub-band decomposition of image is greater than the current threshold then it is said to be significant and classified as positive significant or negative according to sign of this coefficient.

Isolated zero(Z) : if the wavelet coefficient is less than the current threshold value but one or more of its descendants are greater than the current threshold then this coefficient is said to be an Isolated zero root.And zero tree root(T): if the wavelet coefficient and its corresponding descendants are less than the current threshold value then this coefficient is said to be zero tree[18].



In the second pass (subordinate pass) encode the coefficients to 0 or 1 based on the current threshold. These passes are repeated for n cycles reducing the current threshold by 2 until the wanted compression ratio is reached[19].

4- The Proposed hybrid SVD-EZW Technique

Figure (4) explain the compression of proposed technique and figure (5) explain the decompression of proposed technique.

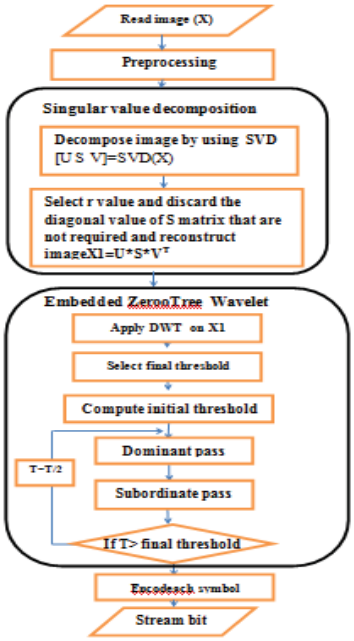


Figure (4) :The block diagram of compression for proposed technique.

Compression stages areexplained in figure(4) and contain the following

Step1: Read image from the file and return image data in an array .The system accept any type of image format.

Step2: Preprocessing steps

a- Adjust image size so that it is result of power 2 (i.e 256×256,512×512…).

b- Convert the image into double type to simplify mathematical operations.

Step3: SVD steps

a- Decomposed preprocessing image in to three matrix as following

[U S V]= SVD(preprocessing image).

b- Select r value.

c- Based on r value discard the diagonal value of S matrix that are not required.

c- Reconstruct image according to equation 2 .

Step 4: EZW steps

a- Apply DWT on the image that result from previous step.

b- Select final threshold.

c-Compute initial threshold according to equation 3.

d-In dominant pass compare wavelet coefficient to the current threshold and gave each coefficient a symbol. Basically there are four symbols for coding (P,N,Z,T) which explain in section (3.3).

e-In subordinate pass encode the coefficients to 0 or 1 based on the current threshold.

f-Repeat steps(c and d) n cycles with reducing the current threshold dividing it by 2 until threshold is less than stop threshold.

g-Encode symbols(P:1110; N:110; Z:10;T:0).

h-At the end obtained on bit stream.

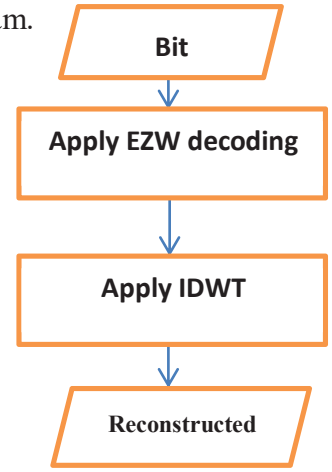


Figure (5) :The block diagram of decompression for proposed technique

Decompression stages are explained in figure(5) and could be summarized as following:

Step1:EZW decoding steps

a- Replace each binary code as follow

(1110 to P, 110 to N ,10 to Z and 0 to T).

b- Dominant pass , if the symbol that obtain from previous step(a) is significant there is data list contains ($1.5T_i$). If symbol isn't significant put 0 in data list.

c- Subordinate pass , if the subordinate list contains 1, update the data list by increment it by ($0.25T_i$). If the subordinate list contains 0, update the data list by decrement it by current ($0.25T_i$).From this step obtain on wavelet coefficient .

Step2:Apply IDWT on the result from step1 and then obtain on the reconstructed image.

4- Performance parameters

In this research use different parameter such as :

- Compression Ratio (CR) [20]

It used to caculate the capability of data compression by comparing the sizes of the image being compressed with the original image.

$$\text{Compression Ratio(CR)} = \left(\frac{uncompressed\ file\ size}{compressed\ file\ size}\right) \quad \text{.....3}$$

- Mean-Squared Error (MSE) [14 15]

It measures a variance between two signals and the result can be comprehend as a degree of resemblance or a strength of error signal between signals.

$$MSE(x, y) = \frac{1}{NM}\sum_{i=1}^{N}\sum_{j=1}^{M}\left(x_{ij} - y_{ij}\right)^2 \quad \text{..... 4}$$

Where x_{ij} is reconstructed image,

y_{ij} is original image.

- Peak Signal to Noise Ratio (PSNR) [21]

Peak Signal to Noise Ratio (PSNR) is used to measure the deformation between the reconstructed image and the original image.

$$PSNR(x, y) = 10\log 10\frac{L^2}{MSE} \quad \text{.....5}$$

Where L=2^8-1 =255.

5- Experiments result & analysis

The proposed lossy image compression was tested on standard test image. The input images are gray and color with size 256*256 and 512*512. In the experiment, we compared the quality of reconstruction image. The performance measuring parameter that used for comparison are CR, PSNR and MSE which are explained previously. Results of the compression are shown in tables and figures Below.

Table (1) showing the result of using hybrid (SVD- EZW) with threshold (50) and threshold (30) with rank (k= 50) and table (2) showing Comparison between EZW, SVD and Hybrid (EZW & SVD)with final threshold (50) compression methods based on (CR).Figures (6 to 7) show the CR and PSNR that obtained by using hybrid method with final threshold 50 and hybrid method with final threshold 30. Figures (8 to 9)show the original images and the reconstructed images after using hybrid (EZW & SVD) with final threshold (50) and hybrid (EZW & SVD) with final threshold (30). Figure (10) shows the CR for SVD,EZW and hybrid method with final threshold 50 and figures (11 to 12) shows the original images and the reconstructed images after using SVD, EZW , hybrid method with final threshold 50 for two images Lena and Cameraman.

Table 1:Shows CR,PSNR,MSE for the proposed technique (SVD-EZW) with threshold (50)and threshold (30)and rank (r=50).

NO.	Image		Size	**hybrid method with threshold 30**				**hybrid method with threshold 50**			
				CR	PSNR	MSE	Size after compression	CR	PSNR	MSE	Size after compression
1	Lena	Gray	65.79	12.65	33.22	5.199	5.199	**31.38**	32.13	36.5	2.096
2		Color	197.02	15.02	33.89	13.113	13.113	**30.47**	32.59	35.8	6.465
3	House color		196.74	17.47	34.5	23.05	11.260	**32.9**	33.34	30.12	5.979

4	Girl color	196.74	18.33	34.47	23.22	10.733	**37.11**	33.01	32.52	5.301
5	Cameraman gray	262.75	24.92	34.97	20.69	10.541	**48.06**	33.62	28.27	5.466
6	Pappers color	786.57	26.73	33.56	28.67	29.423	**50.27**	32.89	33.41	15.646
7	Image 1 color	786.57	43.55	33.86	12.66	18.059	**79.83**	35.92	16.62	9.853
8	Jatplane color	786.57	24.42	34.09	25.37	32.208	**48.97**	33.32	30.30	16.061
9	couble color	196.74	18.20	34.54	22.87	10.809	**38.91**	32.97	32.82	5.056
10	Girl2 color	196.74	17.85	34.92	20.92	11.016	**35.28**	33.4	29.74	5.575
11	Girl3 color	196.74	28.19	37.63	11.23	6.977	**55.82**	35.91	16.66	3.524

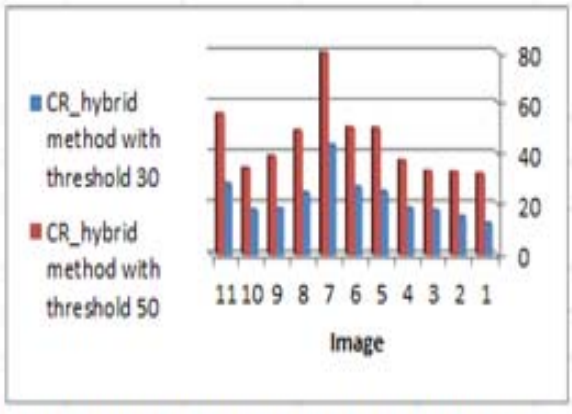


Figure (6): Shows the CR of Hybrid (EZW & SVD) compression method with different threshold.

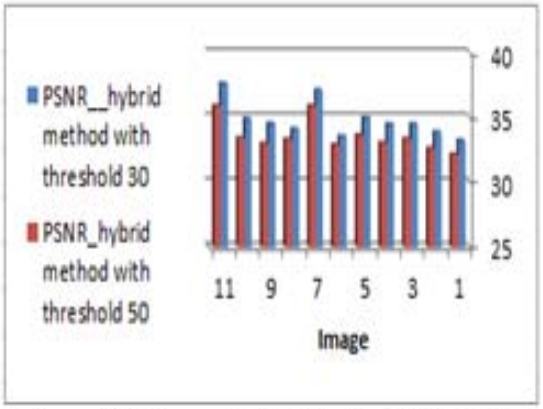


Figure (7):Shows the PSNR hybrid (EZW & SVD) compression method with different threshold.

a b c

Figure (8): (a)original image(b)reconstructed image by using hybrid method with threshold 50 with CR=30.47 (c)reconstructed image by using hybrid method with threshold 30 with CR=15.02.

a b c

Figure (9): (a)original image(b)reconstructed image by using hybrid method with threshold 50 with CR=49.96 (c) reconstructed image by using hybrid method with threshold 30with CR=24.92.

From table (1) and charts (6 to 7) found the CR is achieved by proposed technique with final threshold (50) ismuch higher than the CR that obtained by using proposed technique with final threshold (30).Conversely, peak signal to noise ratio (PSNR) is obtained by the proposed technique with threshold (50) is slightly less than PSNR is obtained by proposed technique with threshold (30). Therefore, it can conclude the compression ratio is decreases as threshold decrease and increases as threshold increases.

Table (2) : Comparison between (EZW), (SVD) and Hybrid (EZW & SVD) for final threshold (30) and (50) compression methods based on (CR).

No	Image	Original size in KB	CR			size after compression in KB		
			SVD	EZW	hybrid method with threshold 50	SVD	EZW with threshold 50	hybrid method with threshold 50

1	Lena	Gray	65.79	1.15	22.55	**25.40**	57	2.917	2.590
2		Color	197.02	1.20	27.88	**30.47**	164	7.066	6.465
3	House color		196.74	1.33	31.98	**32.9**	148	6.151	5.979
4	Girl color		196.74	1.26	35.98	**37.11**	155.32	5.468	5.301
5	Cameraman gray		262.75	1.40	42.69	**48.06**	186.79	6.154	5.466
6	Pappers color		786.57	1.20	43.02	**50.27**	651.76	18.282	15.646
7	Image 1 color		786.57	1.67	78.61	**79.83**	470.75	10.005	9853
8	Jatplane color		786.57	1.30	41.52	**49.01**	601.14	18.942	16.048
9	Couple color		196.74	1.14	38.36	**38.91**	229.23	5.128	5.056
10	Girl2 color		196.74	1.71	33.93	**35.28**	114.45	5.797	5.575
11	Girl3 color		196.74	1.38	55.46	**55.82**	141.74	3.547	3.524

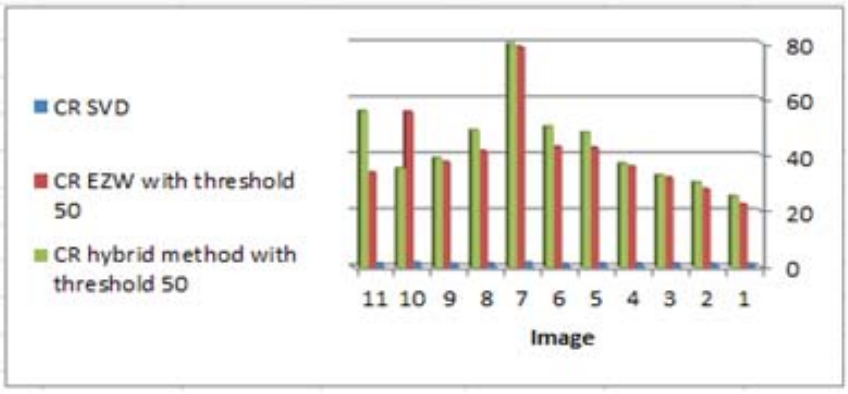


Figure (10): Shows the CR of (EZW), (SVD) and hybrid (EZW & SVD) compression methods.

a b c d

Figure (11):(a) original image 256*256 (b)reconstructed image by using SVD and CR=1.20 (c)reconstructed image by using EZW with threshold 50 the CR= 27.88(d)reconstructed image by using hybrid technique EZW and SVD with threshold 50 the CR=30.47.

a b c

Figure (12): (a) original image 512*512 (b)reconstructed image by using SVD and CR=1.40(c)reconstructed image by using EZW with threshold 50 and CR= 42.69(d)reconstructed image by using hybrid technique EZW and SVD with threshold 50 and CR=48.06.

From table (2) and figure (10)found the CR that are obtained by using hybrid method is higher than the CR that are obtained from other method.

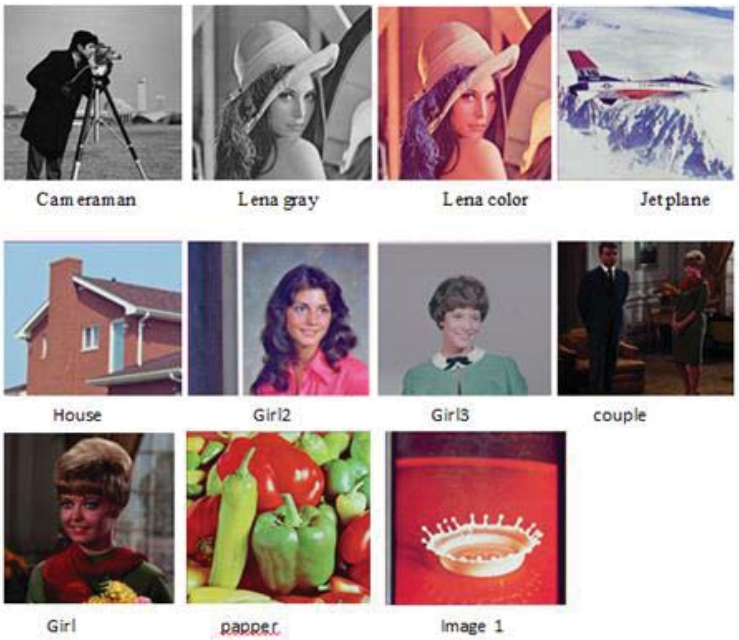


Figure (12):Standard images

6- Conclusion

Choosing the value of threshold is important in calculating the results. From results when final threshold (50), CR is higher than CR when final threshold (30) but PSNR is less than PSNR when final threshold (30). Therefore, PSNR value increases when the threshold value decreases in contrast the CR decreases when threshold value increases. The proposed technique gives a better compression ratio than the other methods compared to the results and according to the table(2). The results obtained by SVD or EZW are a fewer than proposed technique.

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