COMPARATIVE STUDY OF DWT BASED IMAGE COMPRESSION USING HAAR, DAUB & COIF WAVELETS

Er.Rupinder Kaur[1], Dr.Jagroop Singh[2]

[1] PG Student, [2] Associate Professor, Department of ECE,
DAVIET, Jalandhar, (India)

ABSTRACT

Compressing an image is significantly different than compressing raw binary data. General purpose compression programs can be used to compress images, but the result is less than optimal. This is because images have certain statistical properties which can be exploited by encoders specifically designed for them. Also, some of the finer details in the image can be sacrificed for the sake of saving a little more bandwidth or storage space. This also means that lossy compression techniques can be used in this area. The discrete wavelet is essentially sub band coding system and sub band coders have been quite successful in speech and image compression. In this paper we have implemented Haar, Daub & Coif Wavelet Transform. The results in terms of PSNR (Peak Signal Noise Ratio), MSE (Mean Square Error), RMSE (Root Mean Square Error) & Compression Ratio shows that the Haar transformation can be used for image compression. It is clear that DWT has potential application in the compression problem and use of Haar transform is ideally suited. Images requires substantial storage and transmission resources, thus image compression is advantageous to reduce these requirement. The objective of this paper is to evaluate a set of wavelets for image compression. Image compression using wavelet transforms results in an improved compression ratio. Wavelet transformation is the technique that provides both spatial and frequency domain information. This paper presents the comparative analysis of Haar, Daub & Coif wavelets in terms of PSNR, Compression Ratio MSE & RMSE using discrete wavelet transform. Discrete wavelet transform has various advantages over Fourier transform based techniques. DWT removes the problem of blocking artifact that occurs in DCT. DWT provides better image quality than DCT at higher compression ratio.

Keywords: DWT, MSE, PSNR, RMSE, CR

I. INTRODUCTION

One of the important factors for image storage or transmission over any communication media is the image compression. Compression makes it possible for creating file sizes of manageable, storable and transmittable dimensions. A 4MB image will take more than a minute to download using a 64kbps channel, whereas, if the image is compressed with a ratio of 10:1, it will have a size of 400KB and will take about 6 seconds to download. Image Compression techniques are classified into two categories: Lossless and Lossy.

In Lossless techniques the image can be reconstructed after compression, without any loss of information in the entire process. Lossy techniques, on the other hand, are irreversible, because, they involve performing quantization, which results in loss of some information. Some of the commonly used techniques are Transform coding (Discrete Cosine Transform, Wavelet Transform & Gabor Transform), Vector Quantization, Segmentation and Approximation methods, Spline approximation methods (Bilinear Interpolation/Regularization), Fractal coding etc. Wavelet based image compression introduces no blocky artifacts in the decompressed image. The decompressed image is much smoother and pleasant to eyes. Also, we can achieve much higher compression ratios much regardless of the amount of compression achieved.

I present Haar, Daub & Coif Wavelet Transformation for image compression in this research work. The wavelet transform is similar to the Fourier transform (or much more to the windowed Fourier transform) with a completely different merit function. The wavelet transform is often compared with the Fourier transform, in which signals are represented as a sum of sinusoids. The main difference is that wavelets are localized in both time and frequency whereas the standard Fourier transform is only localized in frequency. The Short-time Fourier transform (STFT) is more similar to the wavelet transform, in that it is also a time and frequency localized, but there are issues with the frequency/time resolution trade-off. Wavelets often give a better signal representation using Multi-resolution analysis, with balanced resolution at any time and Frequency. Fourier analysis consists of breaking up a signal into sine waves of various frequencies. Similarly, wavelet analysis is the breaking up of a signal into shifted and scaled versions of the original wavelet.

II. DISCRETE WAVELET TRANSFORM (DWT) FAMILY

DWT now becomes a standard tool in image compression applications because of their data reduction capabilities. DWT can provide higher compression ratios with better image quality due to higher de-correlation property. Therefore, DWT has potentiality for good representation of image with fewer coefficients. The discrete wavelet transform uses filter banks for the construction of the multi-resolution time-frequency plane. The Discrete Wavelet Transform analyzes the signal at different frequency bands with different resolutions by decomposing the signal into an approximation and detail information. The decomposition of the signal into different frequency bands obtained by successive high-pass g (n) and low-pass h (n) filtering of the time domain signal. The basis of Discrete Cosine Transform (DCT) is cosine functions while the basis of Discrete Wavelet Transform (DWT) is wavelet function that satisfies requirement of multi-resolution analysis. DWT processes data on a variable time-frequency plane that matches progressively the lower frequency components to coarser time resolutions and the high-frequency components to finer time resolutions, thus achieving a multi-resolution analysis. The introduction of the DWT made it possible to improve some specific applications of image processing by replacing the existing tools with this new mathematical transform. The JPEG 2000 standard proposes a wavelet transform stage since it offers better rate/distortion (R/D) performance than the traditional discrete cosine transform (DCT). Advantages Compared with DCT, the coefficients of DWT are well localized in not only the frequency, but also the spatial domains. This frequency spatial localization property is highly desired for image compression. Images coded by DWT do not have the problem of block artifacts which the DCT approach may suffer.

The main properties of wavelet functions in image compression are compact support (lead to efficient implementation), symmetry (useful in avoiding de-phasing), orthogonally (allow fast algorithm), regularity, and degree of smoothness (related to filter order or filter length). The compression performance for images with different spectral activity will decides the wavelet function from wavelet family. Daub and Coif wavelets are classes of orthogonal wavelets that are compactly supported. Compactly supported wavelets correspond to finite-impulse response (FIR) filters and, thus, lead to efficient implementation.

Algorithm for Wavelet Transforms

Step 1: Take the original color image.

Step 2: Apply DWT transform (haar, daub2 and coif4).

Step 3: 2D DWT is performed by applying the 1D DWT row wise and then column wise of each component.

Step 4: Perform 1 level of decomposition.

(a) Divide the image into four sub-bands (LL1, LH1, HL1, HH1).

(b) LL1 represent a 2:1 subsampled for vertical and horizontal direction.

(c) LL1, LH1, HL1, HH1 represent a down-sampled of original image needed for perfect reconstruction of original image.

Step 5: stop

Algorithm for Compression

Step 1: Read the original color image.

Step 2: Convert the original color into gray scale image.

Step 3: Apply 2D DWT (haar, daub2 and coif4) to perform compression.

Step 4: Obtained the compressed image.

Step 5: stop

Algorithm for Decompression

Step 1: Input the compressed Image.

Step 2: Apply Inverse DWT (haar, daub2 and coif4) on compressed image.

Step 3: Obtained the decompressed image.

Step 4: stop.

III. PERFORMANCE PARAMETERS

The performance of image compression techniques are mainly evaluated by Compression Ratio (CR), PSNR, MSE & RMSE. The work has been done in MATLAB software. The compressed images are reconstructed into an image similar to the original image by specifying the same DWT coefficients at the reconstruction and by applying inverse DWT.

Mean square error (MSE) is defined as

$$MSE = \frac{1}{MN}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}|x(m,n)-\tilde{x}(m,n)|^2$$

Where M * N is the size of the original image.

Root Mean Square Error (RMSE)

$$RMSE = \sqrt{MSE}$$

Where M and N are the matrix dimensions in x and y respectively

Peak-signal-to-noise-ratio (PSNR)

PSNR is the evaluation standard of the reconstructed image quality, and is an important measure of image compression. The objective performance is measured by **peak signal-to-noise-ratio (PSNR)** of the reconstructed image. PSNR measured in decibels (dB) is given by:

$$PSNR = 10\log_{10}\left(\frac{255^2}{\text{MSE}}\right),$$

Where the value; 255 is the maximum possible value that can be attained by the image signal. Higher the PSNR value is, the better the reconstructed image is.

Compression ratio (CR)

Compression ratio is defined as the nominal bit depth of the original image in bits per pixel (bpp) divided by the bpp necessary to store the compressed image.

$$C_R = \frac{n1}{n2}$$

Where n1 is the number of bits original image and n2 is the compressed image.

IV. RESULTS AND DISCUSSION

DWT technique is used for obtain the desired results. Different wavelets are used at 1st level of decomposition and comparative analysis of Haar, Daub and coif family are displayed. Quantitative analysis has been presented by measuring the values of attained Peak Signal to Noise Ratio and Compression Ratio, MSE & RMSE at 1^{st} decomposition levels. Qualitative analysis has been performed by obtaining the compressed version of the input image by DWT Technique and comparing it with the test image. Our results shows that Haar, Daub and Coif wavelet gives better result in each family and Haar wavelet gives best result as compare to coif wavelet in terms of MSE & PSNR Values.

Qualitative Analysis

We have taken three test images. The Results of Compression & Reconstruction of Images using Different Wavelets techniques are shown below

Test Image (LENA.JPG (256 X 256))

The original image screen which comes when the project is started is as shown below.

Fig.1 Original Lena image

Compression

The compression is performed on original Lena Image using haar, daub2 and coif4 wavelet filter. The Compression results for different Wavelet Techniques are shown below.

Fig.2 Original & Compressed Images

Decompression

The decompression is performed on Lena original image using haar, daub2 and coif4 filter. The Decompression results for different Wavelet Techniques are shown below.

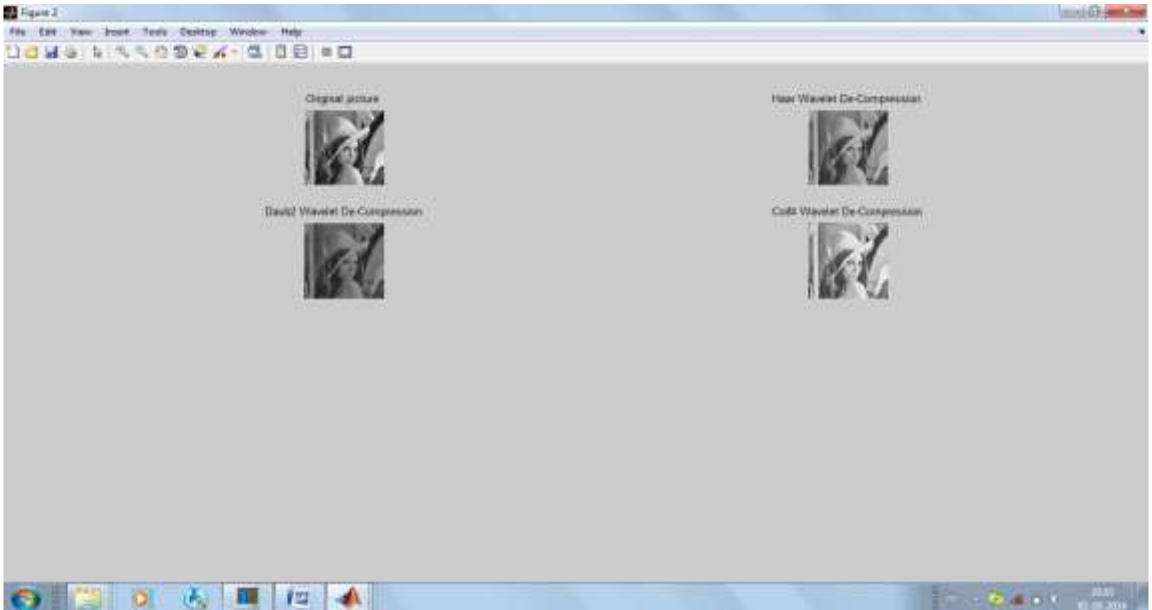


Fig.3 Original & Reconstructed Lena Images using various Wavelet techniques.

Degradation of Image

The degradation in the original image is measured by comparing reconstructed & Original images. The degradation results for the different Wavelet Techniques are shown below.

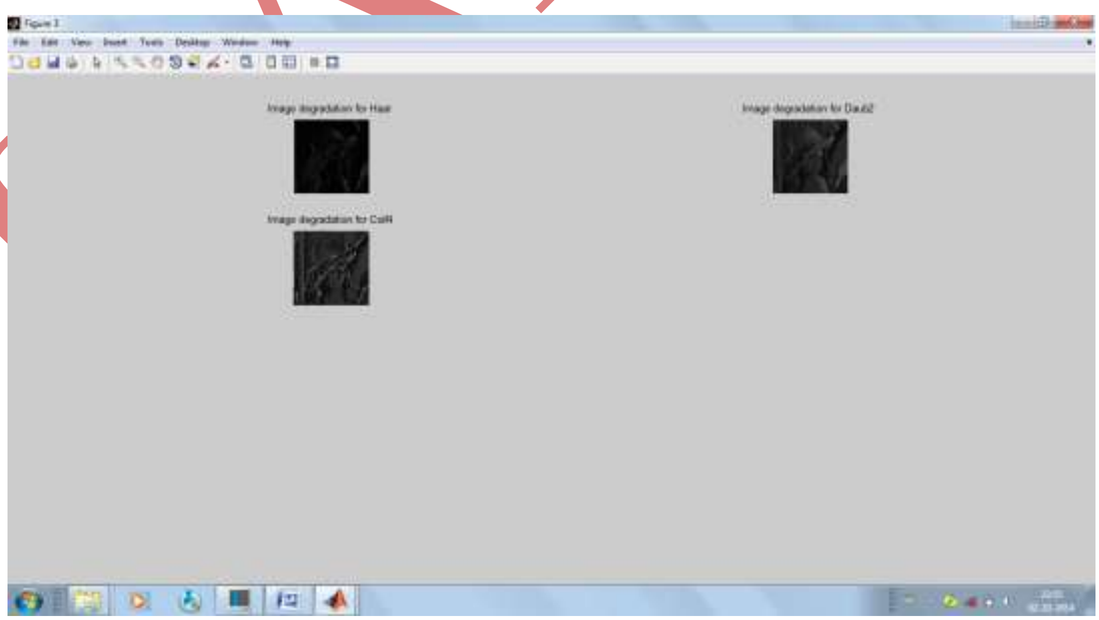


Fig.4 Degraded Images

Test Image (BABOON.JPG (512 X 512))

The original image screen which comes when the project is started is as shown below.

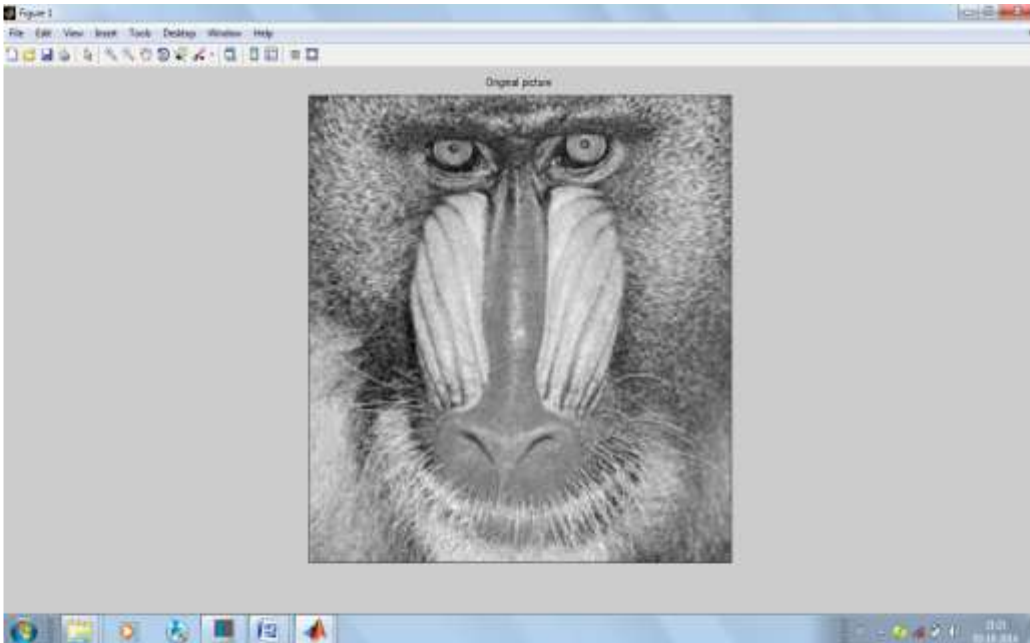


Fig.5 Original Baboon Image

Compression

The compression is performed on original Baboon Image using haar, daub2 and coif4 wavelet filter. The Compression results for different Wavelet Techniques are shown in Fig.6.

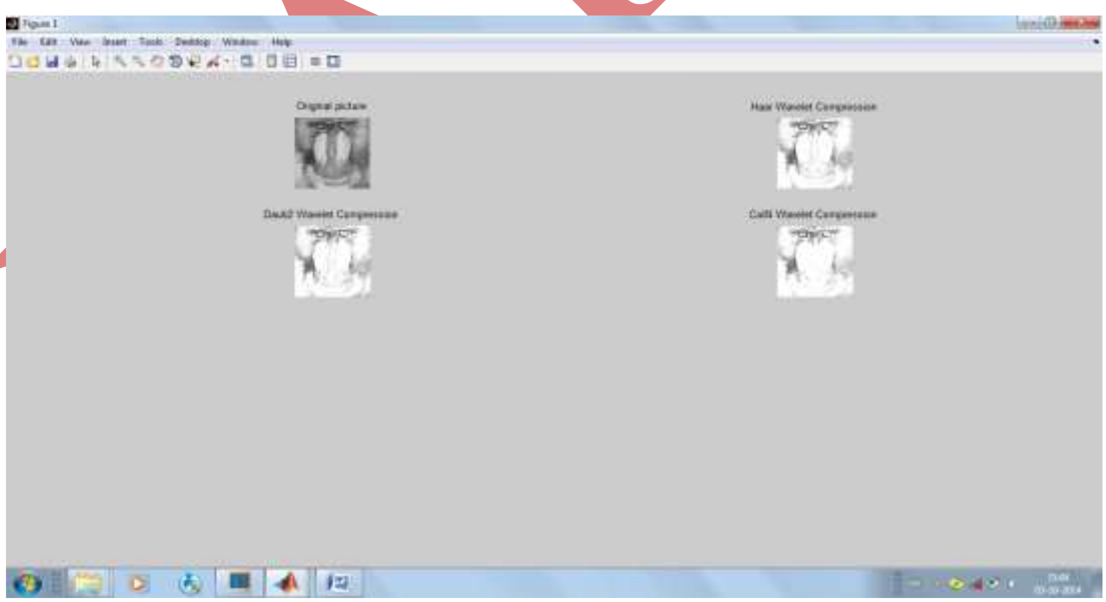


Fig.6 Original & Compressed Images

Decompression

The decompression is performed on original Baboon image using haar, daub2 and coif4 wavelet filter. The Decompression results for different Wavelet Techniques are shown below.

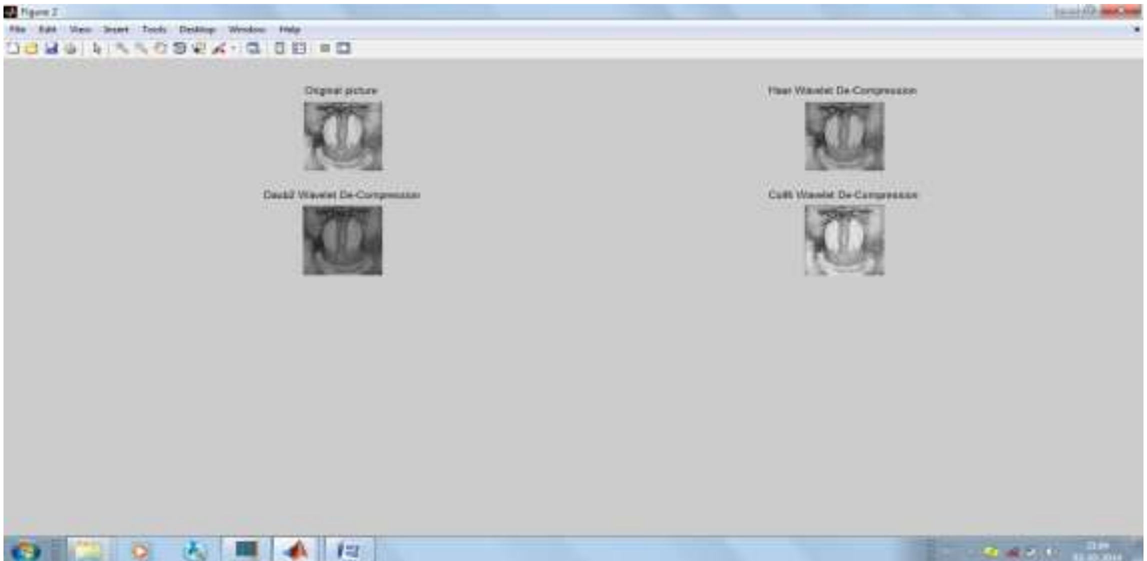


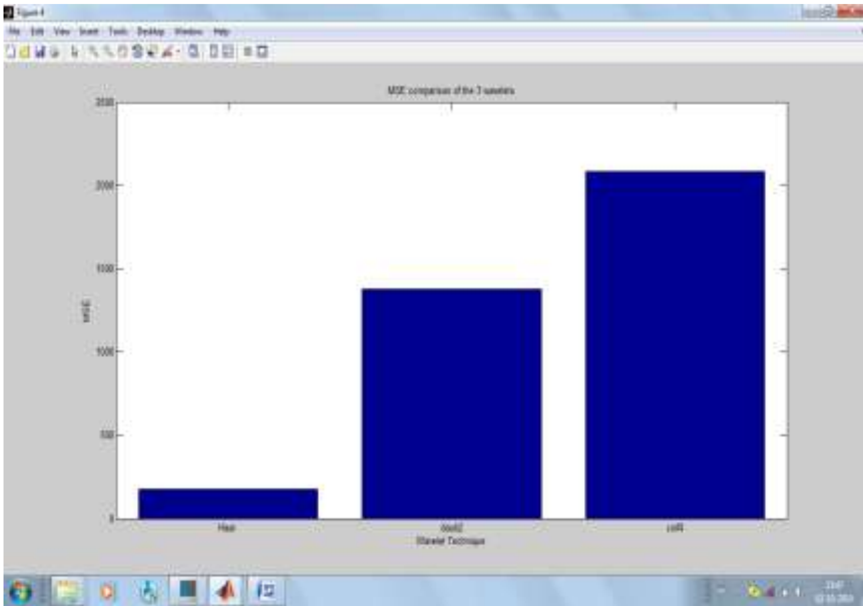
Fig.7 Original & Reconstructed Baboon Images using various Wavelet Techniques

Performance Evaluation for Test Images

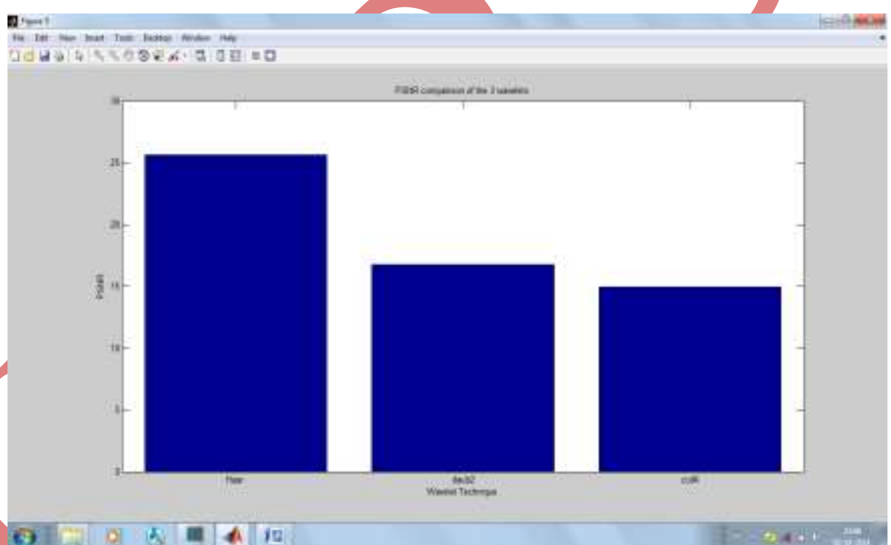
The performance evaluation is done on the basis of MSE, PSNR, CR and RMSE.

Table-1 MSE, PSNR, CR & RMSE Comparison for LENA.JPG

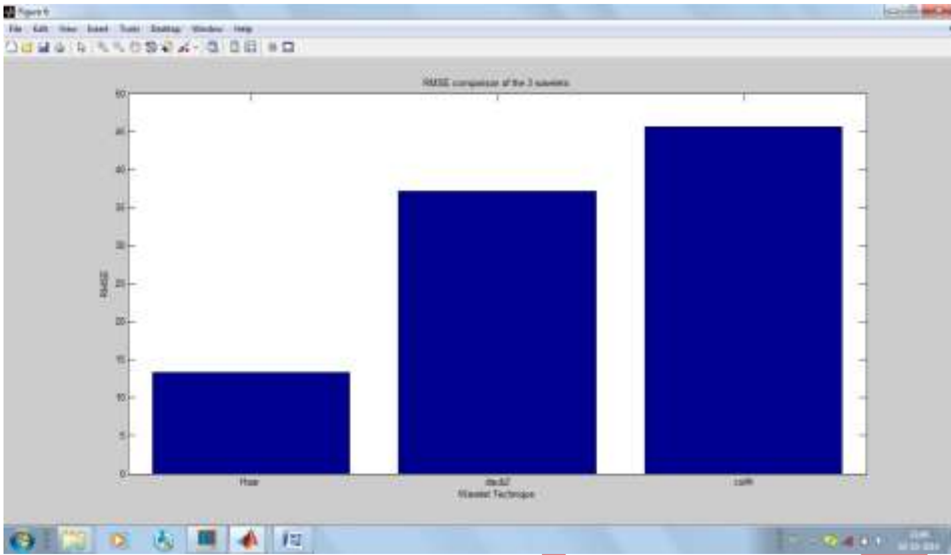
Wavelet Filters	MSE	PSNR	CR	RMSE
Haar	178.5236	25.6138	119.2700	13.3613
Daub2	1.3780e+003	16.7385	119.2700	37.1208
Coif4	2.0824e+003	14.9452	136.1345	45.6331



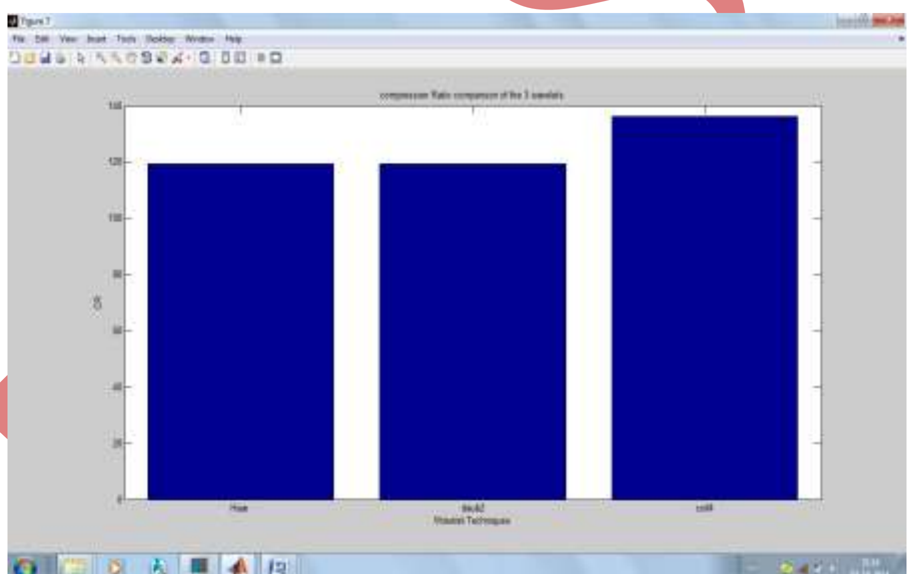
Graph 1: MSE for Lena Image



Graph 2: PSNR for Lena Image



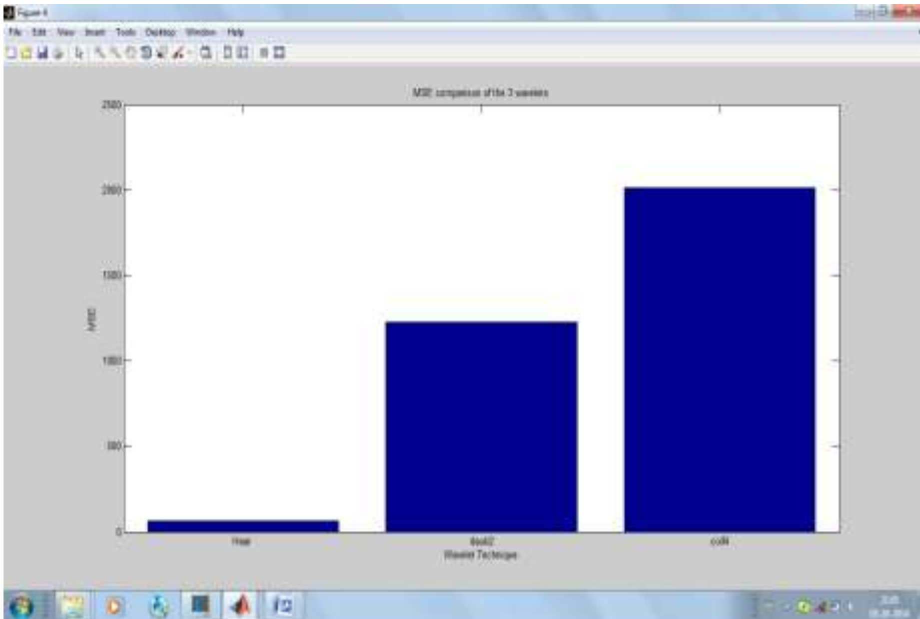
Graph 3: RMSE for Lena Image



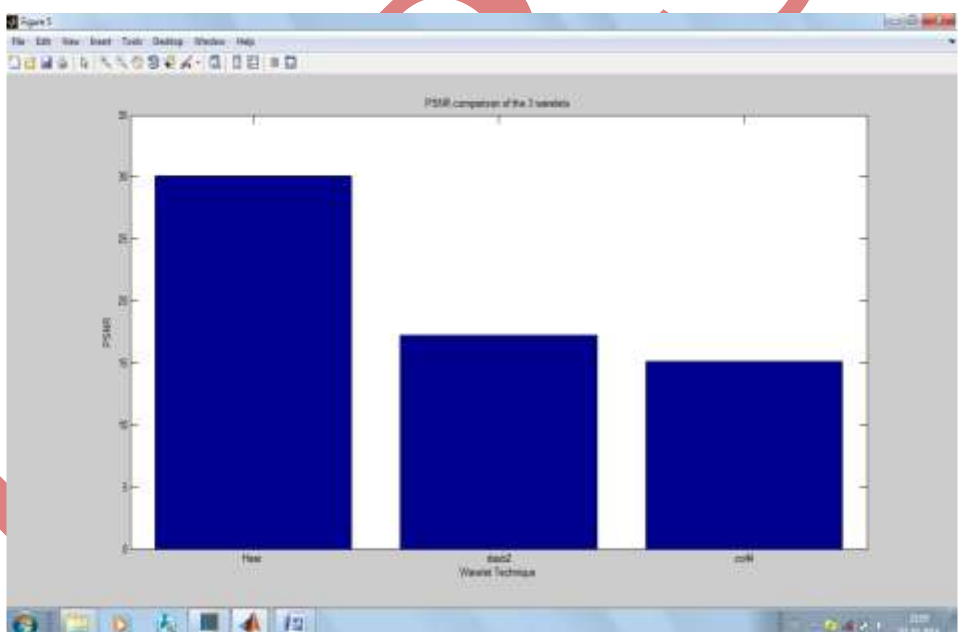
Graph 4: CR for Lena Image

Table-2 MSE, PSNR, CR & RMSE Comparison for BABOON.JPG

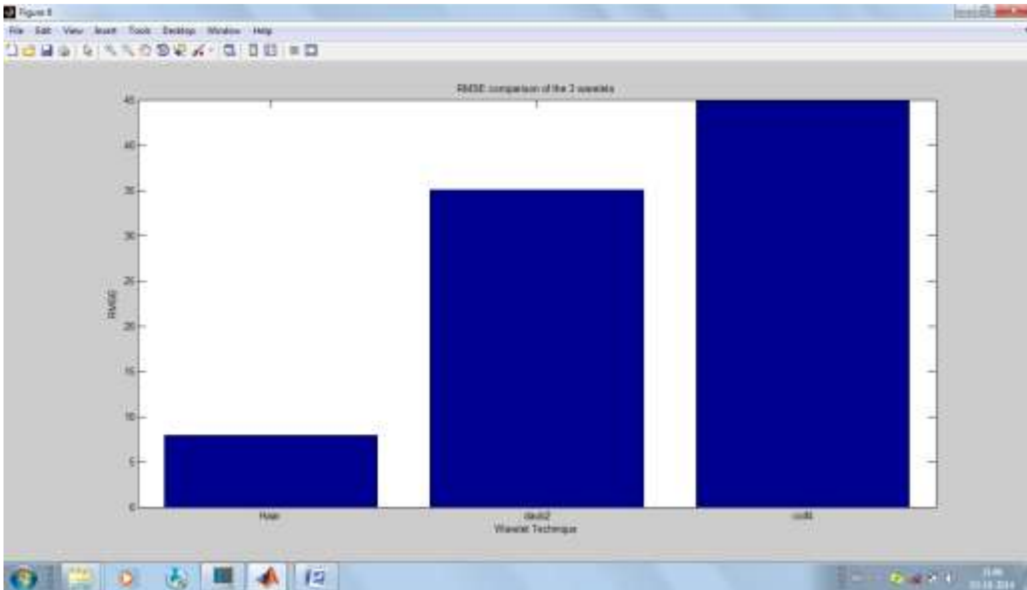
Wavelet Filters	MSE	PSNR	CR	RMSE
Haar	63.3516	30.1132	123.4451	7.9594
Daub2	1.2251e+003	17.2491	123.4451	35.0014
Coif4	2.0114e+003	15.0957	142.0138	44.8491



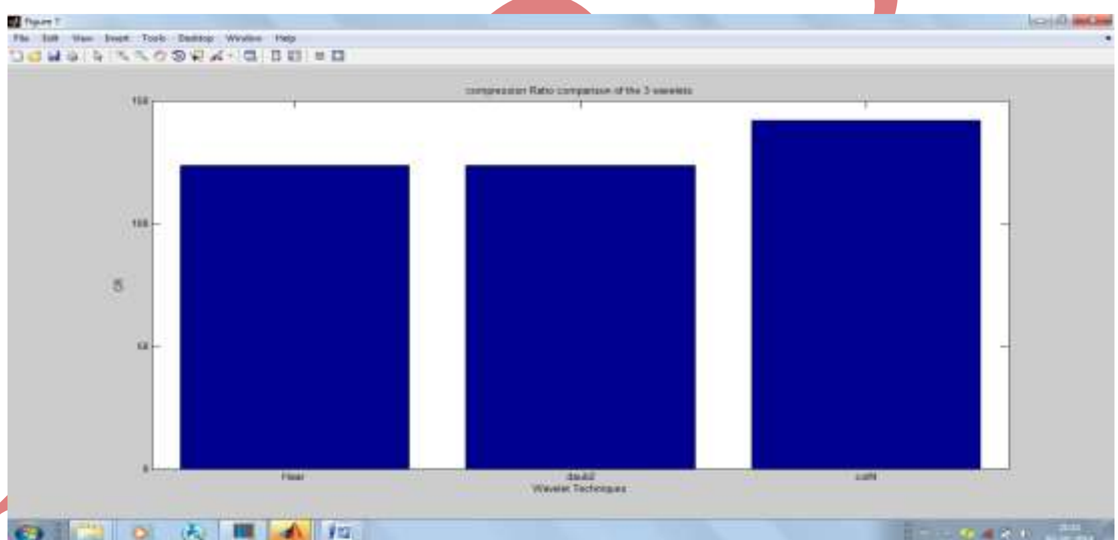
Graph 1 MSE for Baboon Image



Graph 2 PSNR for Baboon Image



Graph 3 RMSE for Baboon Image



Graph 4 CR for Baboon Image

Results show that Haar Wavelet Provides Lowest MSE & Good PSNR values as compared to other Wavelets. Coif 4 Provides Good Compression Ratio.

V. CONCLUSION & FUTURE SCOPE

In this paper, the results are obtained at 1st level of decomposition. PSNR, CR, RMSE & MSE results for each wavelet are compared. From results we conclude that results obtain at 1st level of decomposition gives better results in terms of PSNR, CR & RMSE and results of Haar wavelet is better than Daub and Coif family. Results show that Haar

Wavelet Provides Lowest MSE & Good PSNR values as compared to other Wavelets. Coif 4 Provides Good CR (Compression Ratio).

REFERENCES

[1] M. Antonini, M. Barlaud, P. Mathieu, and I. Daubechies, "Image coding using wavelet transform," IEEE Transactions on Image Processing, Vol. 1, pp. 205-220, April 1992.

[2] H. Guo and C. Burrus, "Wavelet Transform based Fast Approximate Fourier Transform," in Proceedings of IEEE International Conference on Acoustics, Speech, and Signal Processing, Vol. 3, pp. 1973-1976, April 1997.

[3] Dragotti P. L, Poggi G, "Compression of multispectral Images by three-dimensional SPIHT algorithm", IEEE Trans. on Geoscience and Remote Sensing, Vol. 38, No. 1, Jan 2000.

[4] Grgic,Sonja., Grgic,Mislav.,"Performance Analysis of Image Compression Using Wavelets",IEEE Trans,Vol.48,No.3,June 2001.

[5] Gao, Zigong, Yuan F.Zheng, "Quality Constrained Compression Using DWT Based Image Quality Metric",IEEE Trans,September 10, 2007.

[6] Kumari,Sarita., Vijay,Ritu., "Analysis of Orthogonal and Biorthogonal Wavelet Filters for Image Compression", International Journal of Computer Applications , Vol. 21, No. 5, May 2011.

[7] Katharotiya Anil kumar, Patel Swati, "Comparative Analysis between DCT & DWT Techniques of Image Compression", Journal of Information Engineering and Applications, Vol. 1, No.2, 2011.

[8] Gupta Maneesha., garg, Amit Kumar.,Kaushik ,Mr.Abhishek., "Review: Image Compression Algorithm", IJCSET, Vol. 1, Issue 10, November 2011.

[9] Kaleka Jashanbir Singh, Sharma Reecha, "Comparative performance analysis of Haar, Symlet and Bi-orthogonal wavelets on image compression using Discrete wavelet Transform", International Journal of Computers and Distributed Systems, Vol. 1, Issue 2, August 2012.

[10] Kumar V, V. Sunil, Reddy M. Indrasena, "Image Compression Techniques by using Wavelet Transform", Journal of Information Engineering and Applications, Vol. 2, No.5, 2012.

[11] J.Abirami, K.Narashiman S.SivaSankari, S.Ramya, "Performance analysis of image compression using wavelet thresholding", Proceedings of IEEE Conference on Information and Communication Technologies, (ICT 2013).

[12] Sandeep Kaur, Gaganpreet Kaur, Dr.Dheerendra Singh, "Comparative Analysis of Haar and Coiflet Wavelets Using Discrete Wavelet Transform in Digital Image Compression", International Journal of Engineering Research and Applications, Vol. 3, Issue 3, May-Jun 2013.

[13] H. B. Kekre, Tanuja Sarode and Prachi Natu, "Efficient Image Compression Technique using full Column and Row Transforms on Colour Image", International Journal of Advances in Engineering & Technology, Vol. 6, Issue 1, 2013.