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A COMPARATIVE STUDY OF IMAGE COMPRESSION ALGORITHMS

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Abstract: *Digital images in their uncompressed form require an enormous amount of storage capacity. Such uncompressed data needs large transmission bandwidth for the transmission over the network. Discrete Cosine Transform (DCT) is one of the widely used image compression method and the Discrete Wavelet Transform (DWT) provides substantial improvements in the quality of picture because of multi resolution nature. Image compression reduces the storage space of image and also maintains the quality information of the image. In this study the performance of three most widely used techniques namely DCT, DWT and Hybrid DCT-DWT are discussed for image compression and their performance is evaluated in terms of Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) and Compression Ratio (CR). The experimental results obtained from the study shows that the Hybrid DCT- DWT technique for image compression has in general a better performance than individual DCT or DWT.*

Keywords: *Compression, DCT, DWT, Hybrid, Image Compression.*

I. INTRODUCTION

Compression is a process by which the description of computerized information is modified so that the capacity required to store or the bit-rate required to transmit it is reduced. Compression is carried out for the following reasons as to reduce, the storage requirement, processing time and transmission duration. Image compression is minimizing the size in bytes of a graphics file without degrading the quality of image. Many applications need large number of images for solving problems. Digital images can be stored on disk, and storing space of image is important. Because less memory space means less time required for processing of image. Image Compression means reducing the amount of data required to represent a digital image [1].

The joint photographic expert group (JPEG) was developed in 1992, based on DCT. It has been one of the most widely used compression method [2]. The hardware implementation for the JPEG using the DCT is simple; the noticeable "blocking artifacts" across the block boundaries cannot be neglected at higher compression ratio. In images having gradually shaded areas, the quality of reconstructed images is degraded by "false Contouring" [3]. In DWT based coding, has ability to display the images at different resolution and also achieves higher compression ratio. The Forward Walsh Hadamard Transform (FWHT) is another option for image and video compression applications which requires less computation as compared to DWT and DCT algorithms. In order to benefit from the respective strengths of individual popular coding scheme, a new scheme, known as hybrid algorithm, has been developed where two transform techniques are implemented together. Yu and Mitra in [4] have introduced Hybrid transform coding technique. Similarly Usama presents a scalable Hybrid scheme for image coding which combines both the wavelets and Fourier transform [5]. In [6], Singh et al. have applied hybrid algorithm to medical images that uses 5 - level DWT decomposition. Because of higher level (5 levels DWT) the scheme requires large computational resources and is not suitable for use in modern coding standards. In this section, DCT, DWT and Hybrid DCT-DWT techniques are discussed.

A. Discrete Cosine Transform

A DCT represents the input data points in the form of sum of cosine functions that are oscillating at different frequencies and magnitudes. There are mainly two types of DCT: one dimensional DCT and two dimensional DCT. The 2D DCT for an N×N input sequence can be defined as follows [7]:

$$D_{DCT}(i,j) = \frac{1}{\sqrt{2n}} B(i)B(j) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} M(x,y)$$

$$. \cos\left[\frac{2x+1}{2N} i\pi\right] \cos\left[\frac{2y+1}{2N} j\pi\right] \quad (1)$$

Where B (u) = $\begin{cases} \frac{1}{\sqrt{2}} \; if \; u = 0, \\ 1 \text{ if u } > 0 \end{cases}$

M (x,y) is the input data of size x×y. The input image is first divided into 8×8 blocks; then the 8-point 2-D DCT is performed. The DCT coefficients are then quantized using an 8×8 quantization table. The quantization is achieved by dividing each elements of the transformed original data matrix by corresponding element in the quantization matrix Q and rounding to the nearest integer value as shown in equation (2):-

$$D_{quant}(i,j) = round\left\{\frac{D_{DCT}(i,j)}{Q(i,j)}\right\} (2)$$

After this, compression is achieved by applying appropriate scaling factor. Then in order to reconstruct the data, rescaling and de-quantization is performed. The de-quantized matrix is then transformed back using the inverse – DCT. The whole procedure is shown in Fig. 1.

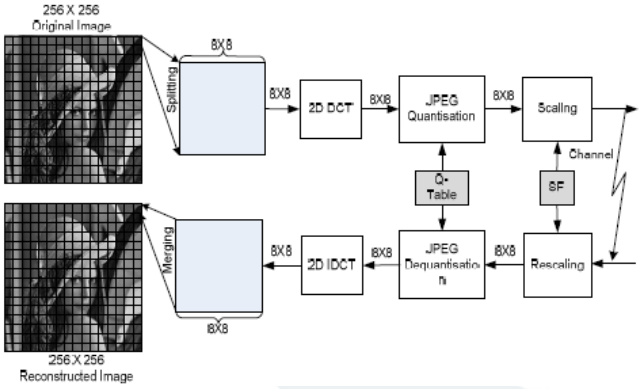

Figure 1: Block diagram of the JPEG-based DCT scheme

B. Discrete Wavelet Transform

In DWT, an image is represented by sum of wavelet functions, which are known as wavelets, having different location and scale. Discrete Wavelet Transform represents the data into a set of high pass (detail) and low pass (approximate) coefficients. Image is first divided into blocks of 32×32. Then each block is passed through two filters: in this the first level, decomposition is performed to decompose the input data into an approximation and detail coefficients. After obtaining the transformed matrix, the detail and approximate coefficients are separated as LL, HL, LH and HH coefficients. Then all the coefficients are discarded, except the LL coefficients that are transformed into the second level. These coefficients are then passed through a constant scaling factor to achieve the desired compression ratio. Following fig. 2 is an illustration of DWT. Here, x[n] is the input signal, d[n] is the high frequency component, and a[n] is the low frequency component. For data reconstruction, the coefficients are rescaled and padded with zeros, and passed through the wavelet filters. We have used the Daubechies filters coefficients in this study [9]:

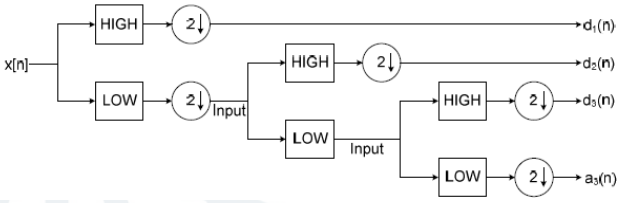

Figure 2: Block diagram of the 2- level DWT scheme

C. Hybrid DWT-DCT Algorithm

The objective of the hybrid DWT-DCT algorithm is to exploit the properties of both DWT and DCT. By giving consideration to the type of application, original image of size 256×256 or any resolution, provided divisible by 32, is first divided into blocks of N×N. Then each block is decomposed using 2-D DWT. Now low frequency coefficients (LL) are passed to the next stage where the high frequency coefficients (HL, LH, and HH) are discarded. Then the passed LL components are further decomposed using another 2_D DWT. The 8-point DCT is applied to the DWT Coefficients. To achieve a higher compression, majority of high coefficients can be discarded. To achieve more compression a JPEG like quantization is performed. In this stage, many of the higher frequency components are rounded to zero. The quantized coefficients are further scaled using scaling factor (SF). Then the image is reconstructed by following the inverse procedure. During inverse DWT, zero values are padded in place of detailed coefficients [10].

II. PERFORMANCE EVALUATION PARAMETERS

Two popular measures of performance evaluation are, Peak Signal to noise Ratio (PSNR) and Compression Ratio (CR). Which are described below:

A. PSNR

It is the most popular tool for the measurement of the compressed image and video. It is simple to compute. The PSNR in decibel is evaluated as follows [15]:

$$\text{PSNR} = 10 \log_{10} \frac{I^2}{\text{MSE}} (3)$$

Where, I is allowable image pixel intensity level.

MSE is mean squared error. It is another performance evaluation parameter of Image Compression Algorithms. It is an important evaluation parameter for measuring the quality of compressed image. It compares the original data with reconstructed data and then results the level of distortion. The MSE between the original data and reconstructed data is:

$$MSE = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} (A_{i,j} - B_{i,j})^2 \quad (4)$$

Where, A = Original image of size M×N

B = Reconstructed image of size M×N

B. CR

It is a measure of the reduction of detail coefficient of data.

$$CR = \frac{\text{Discarded Data}}{\text{Original Data}}$$

In the process of image compression, it is important to know how much important coefficient one can discard from input data in order to preserve critical information of the original data.

III. LITERATURE SURVEY

Anil Kumar *et al.* in their paper two image compression techniques namely, DCT and DWT are simulated. They concluded that DWT technique is much efficient than DCT in quality and efficiency wise but in performance time wise DCT is better than DWT [1].

Swastik Das *et al.* presented DWT and DCT transformations with their working. They concluded that image compression is of prime importance in Real time applications like video conferencing where data are transmitted through a channel. Using JPEG standard, DCT is used for mapping which reduces the inter pixel redundancies followed by quantization which reduces the psycho visual redundancies then coding redundancy is reduced by the use of optimal code word having minimum average length. In JPEG 2000 standard of image compression DWT is used for mapping, all other methods remaining same. They analysed that DWT is more general and efficient than DCT [11].

Rupinder Kaur *et al.* outline the comparison of compression methods such as RLE (Run Length Encoding), JPEG 2000, Wavelet Transform, SPIHT (Set Partition in Hierarchical Trees) on the basis of compression ratio and compression quality. The comparison of these compression methods are classified according to different medical images on the basis of compression ratio and compression quality. Their results illustrate that they can achieve higher compression ratio for MRI, Ultrasound, CT scan and iris images by SPIHT method. Furthermore they also observe that for MRI image wavelet compression method has higher compression ratio and has good PSNR value for iris image than JPEG method. Compression ratio is almost same of iris and MRI image. For CT scan image JPEG compression method outperforms the PSNR and degree of compression than wavelet compression method [12].

Rehna *et al.* discussed different hybrid approaches to image compression. Hybrid coding of Images, in this context, deals with combining two or more traditional approaches to enhance the individual methods and achieve better quality reconstructed images with higher compression ratio. They also reviewed literature on hybrid techniques of image coding over the past years. They did a detailed survey on the existing and most significant hybrid methods of Image coding. And every approach is found to have its own merits and demerits. They also concluded that good quality reconstructed images are obtained, even at low bit rates when wavelet based hybrid methods are applied to image coding. They concluded that the existing conventional image compression technology can be developed by combining high performance coding algorithms in appropriate ways, such that the advantages of both techniques are fully exploited [13].

IV. OBJECTIVE OF THE STUDY

The objective of this research study is to compare the performance of three most widely used techniques namely DCT, DWT and Hybrid DCT-DWT in terms of Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) and Compression Ratio (CR).

V. EXPERIMENTAL RESULTS

To test the performance of Hybrid DCT-DWT with standalone DCT and DWT, researchers implemented the algorithms in Matlab. To conduct the research study, various types of images are used namely, natural images and medical images. Images are used to verify the efficiency of Hybrid DCT-DWT algorithm and are compared with standalone DCT and DWT algorithm. Images in raw form are difficult to obtain hence already compressed medical images downloaded from "www.gastrolab.net" in JPEG format is considered for analysis. The following figures show the result of image compression by DCT, DWT and Hybrid DCT-DWT respectively.

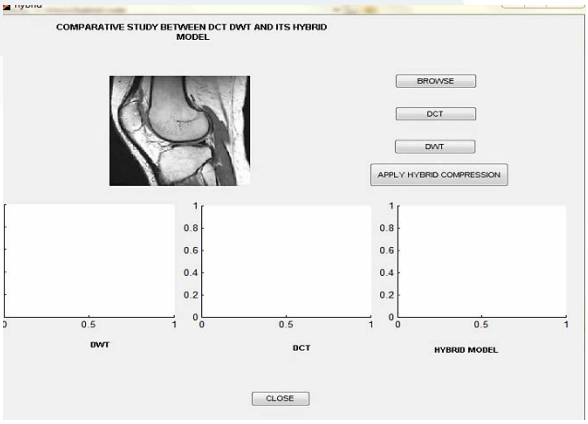

Figure 3: Loading of an original image

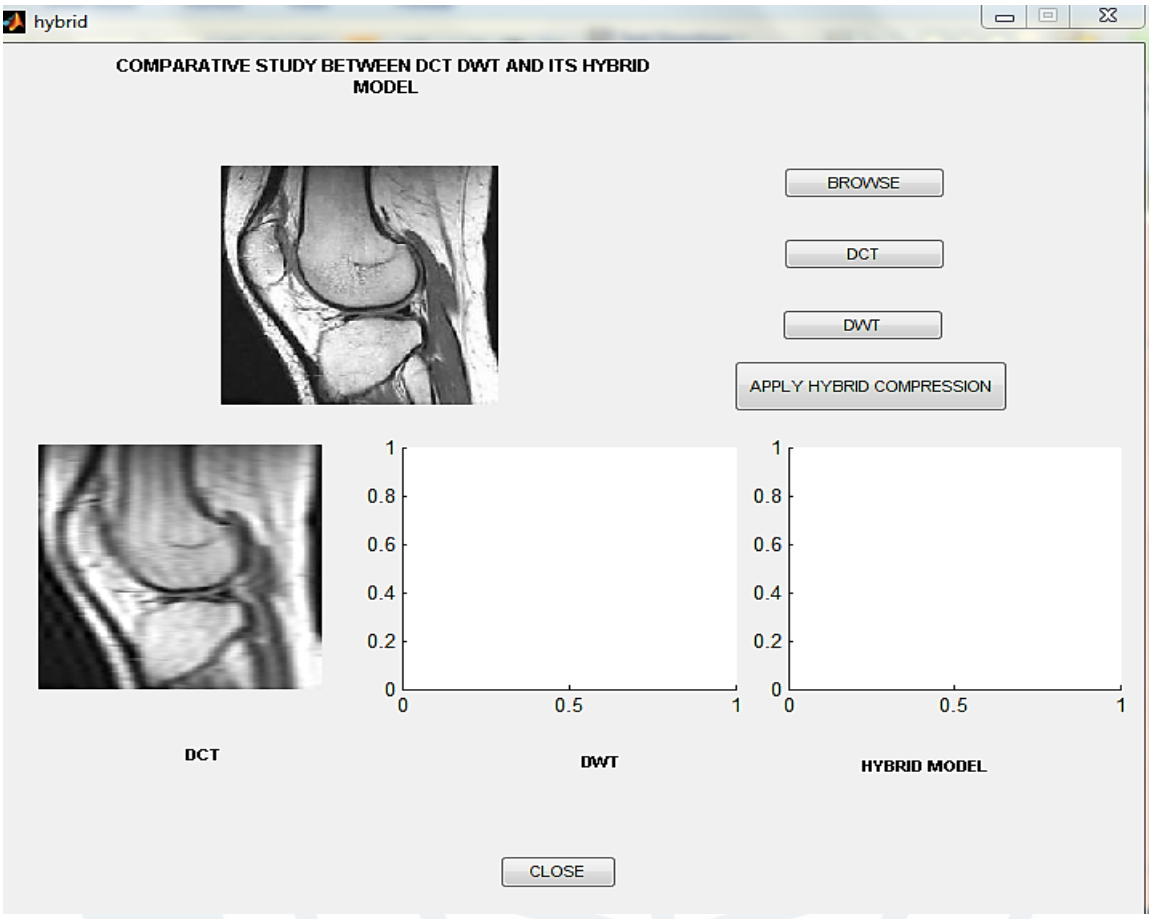

Figure 4: DCT image after processing

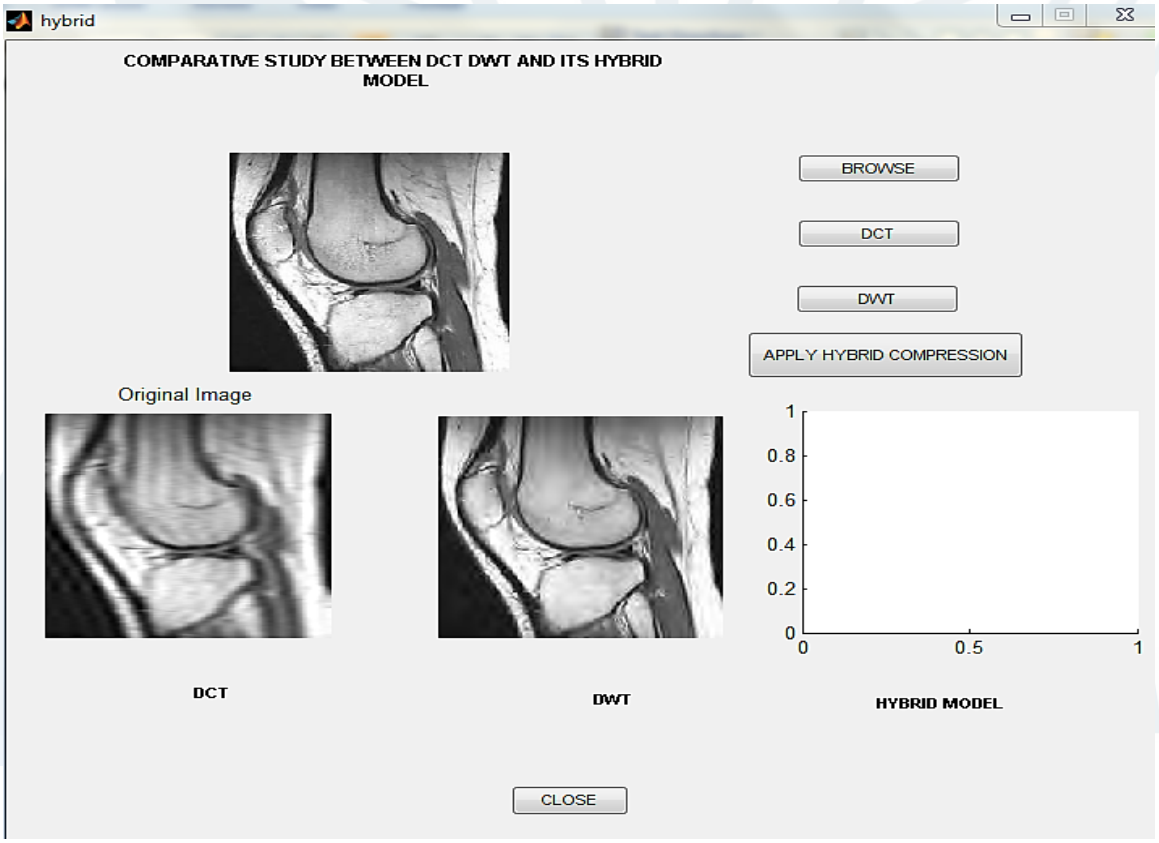

Figure 5: DWT image after processing

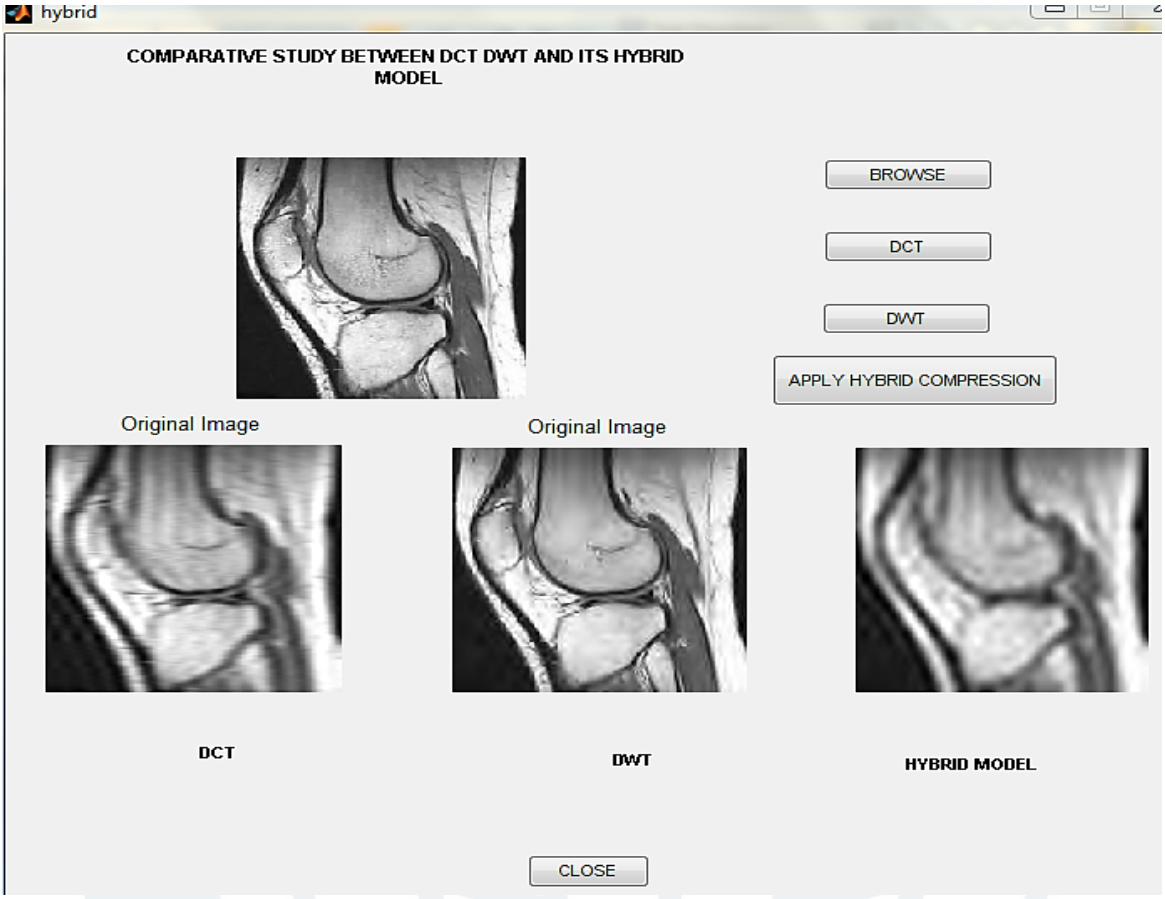

Figure 6: Hybrid DWT-DCT image after processing

Following *figure 7* shows the PSNR values (measured in decibel) of five compressed images for average compression ratio of 96% by DWT, DCT and Hybrid DCT-DWT techniques respectively.

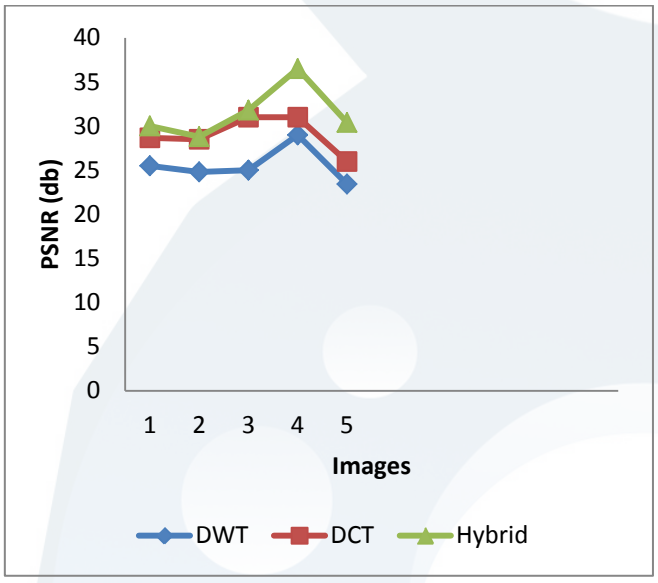

Figure 7: PSNR of images for average compression ratio of 96%

Similarly, *figure 8* shows the compression ratio of images for average PSNR of 32 db, when compressed by DWT, DCT and Hybrid DCT-DWT techniques.

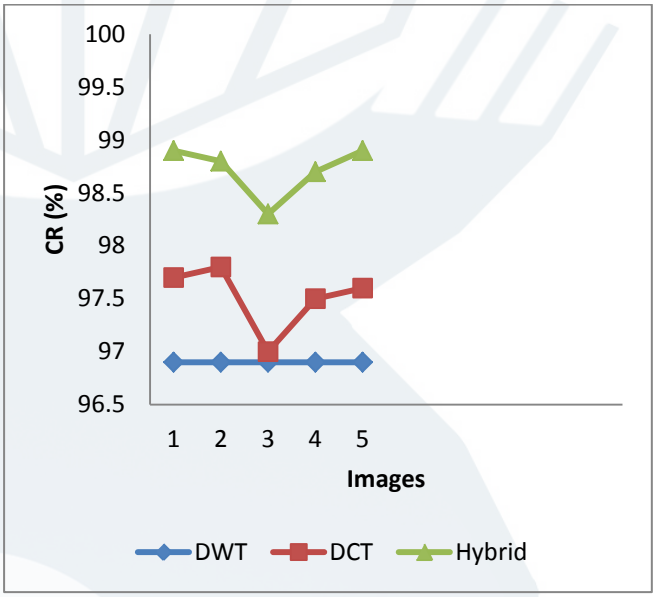

Figure 8: CR of images for average PSNR of 32 db

VI. CONCLUSION AND FUTURE SCOPE

It is observed from the results that the Hybrid DCT-DWT algorithm for image compression has better performance as compared to the other standalone techniques, namely DWT and DCT. The performance comparison is done by considering the performance criteria i.e. PSNR, MSE and Compression Ratio. By comparing the performances of these techniques using

the above mentioned parameters and JPEG image format, we found the various deficiencies and advantages of the techniques. We find out that DWT technique is more efficient by quality wise than DCT and by performance wise DCT is much better than DWT. But, overall performance of Hybrid DCT-DWT is much better than the others. On the basis of the results of the performance comparison, in future, the researchers will either be able to design a new transform technique or will be able to remove some of the deficiencies of these transforms.

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