Comparative Analysis between DCT and DWT Techniques of Image Compression

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1 Abstract

Image compression is a method through which we can reduce the storage space of images, videos which will helpful to increase storage and transmission process's performance. In image compression, we do not only concentrate on reducing size but also concentrate on doing it without losing quality and information of image.
we present the comparison of the performance of Discrete cosine transform, Discrete wavelet transform and Haar Wavelet for implementation in a still image compression system and to highlight the benefit of these transforms relating to today's methods. The performance of these transforms are compared in terms of Signal to noise ratio SNR, Mean squared error (MSE) and Energy Retained (ER).

2 Introduction

In modern day, many applications need large number of images for solving problems. Digital image can be store on disk. This storing space of image is also important. Because less memory space means less time of required to processing for image. Here the concept of image compression comes. "Image compression means reduced the amount of data required to represent a digital image". There are many applications where the image compression is used to effectively increased efficiency and performance. Application are like Health Industries, Retail Stores, Federal Government Agencies, Security Industries, Museums and Galleries etc.

3 Evaluation matrix

$$PSNR = 10\log_{10}\left(\frac{{MAX_i}^2}{MSE}\right) \tag{1}$$

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2 \qquad (2)$$

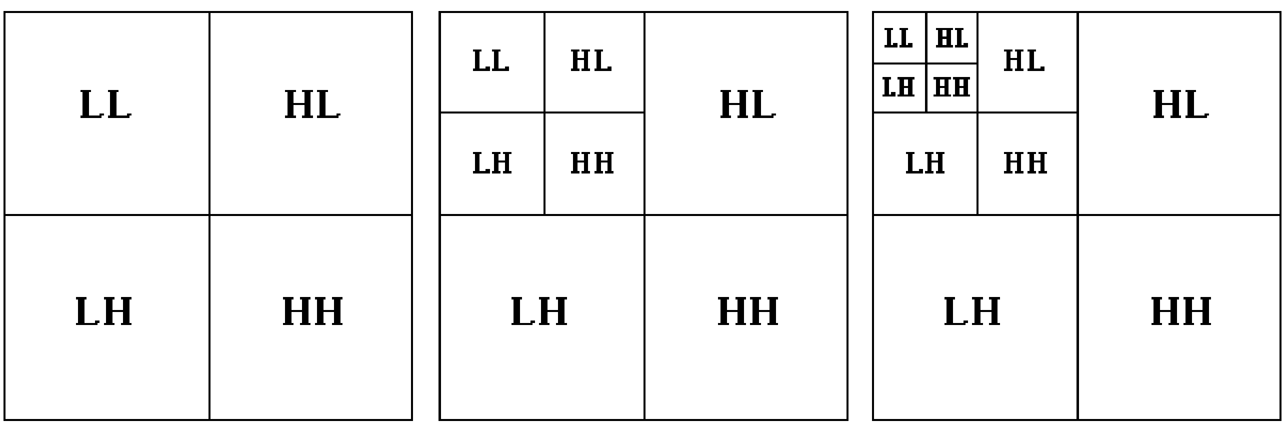
4 Methodology

In this project we work on two types of image compression techniques which are :

(a). Haar Wavelet Transform Technique
(b).Discrete Cosine Transform technique

4.1 Haar Wavelet Transform (DWT)

Wavelet analysis can be used divided the information of an image into approximation and detailed sub signal. The approximation sub signal shows the general trend of pixel value, and three detailed sub signal show vertical, horizontal and diagonal details or changes in image. If these detail is very small than they can be set to zero without significantly changing the image.



(a) Single Level Decomposition (b) Two Level Decomposition (c) Three Level Decomposition

If the number of zeroes is greater than the compression ratio is also greater. There is two types of wavelet is used. First one is Continues wavelet transform and second one is Discrete wavelet transform. Wavelet analysis is computed by filter bank. There is two type of filter a) High pass filter: high frequency information is kept, low frequency information is lost. b) Low pass filter: law frequency information is kept, high frequency information is lost. So signal is effectively decomposed into two parts, a detailed part(high frequency) and approximation part(law frequency). Level 1 detail is horizontal detail, level2 detail is vertical detail and level 3 detail is diagonal detail of the image signal.

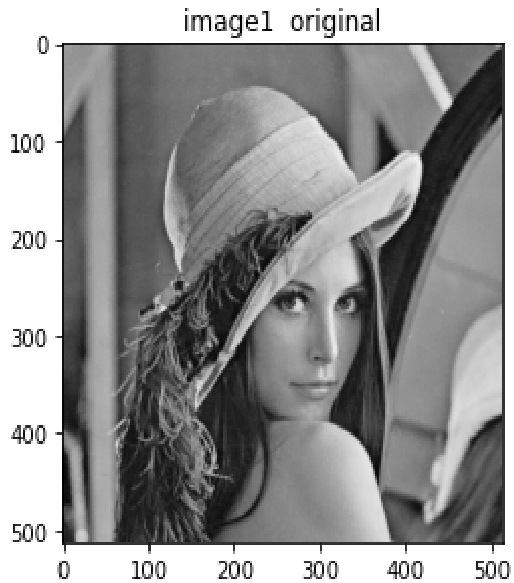


Figure 1: input image 1

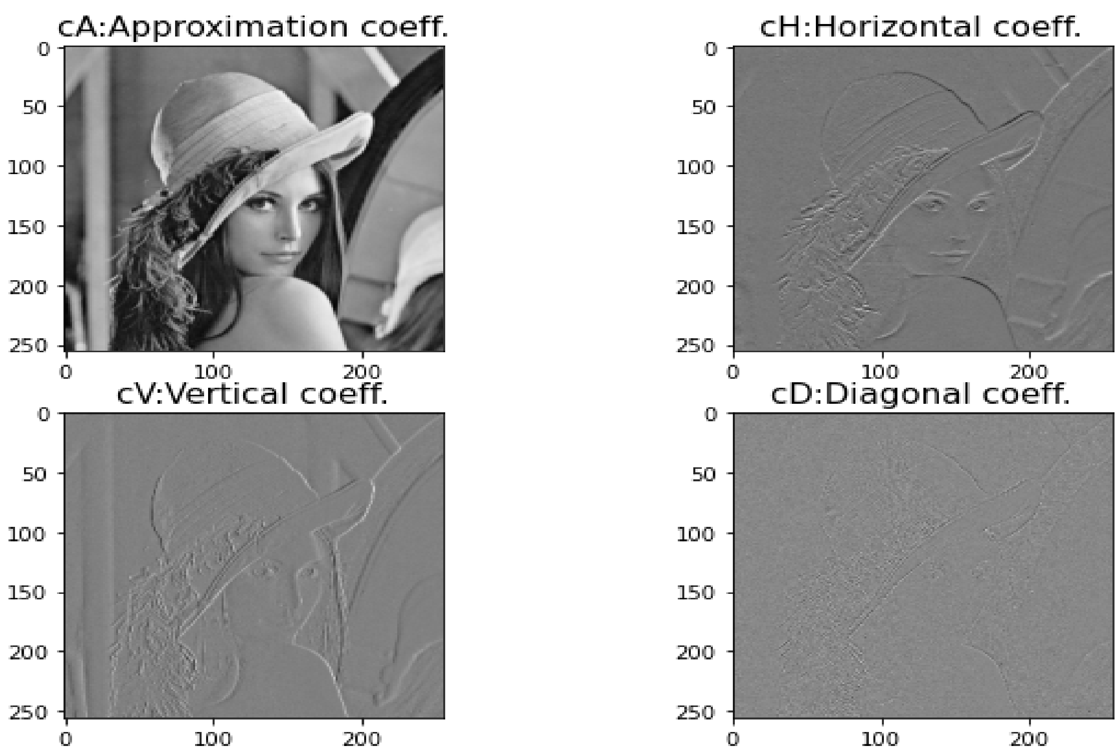


Figure 2: De-composition of image

Figure 3: original image and reconstruct image

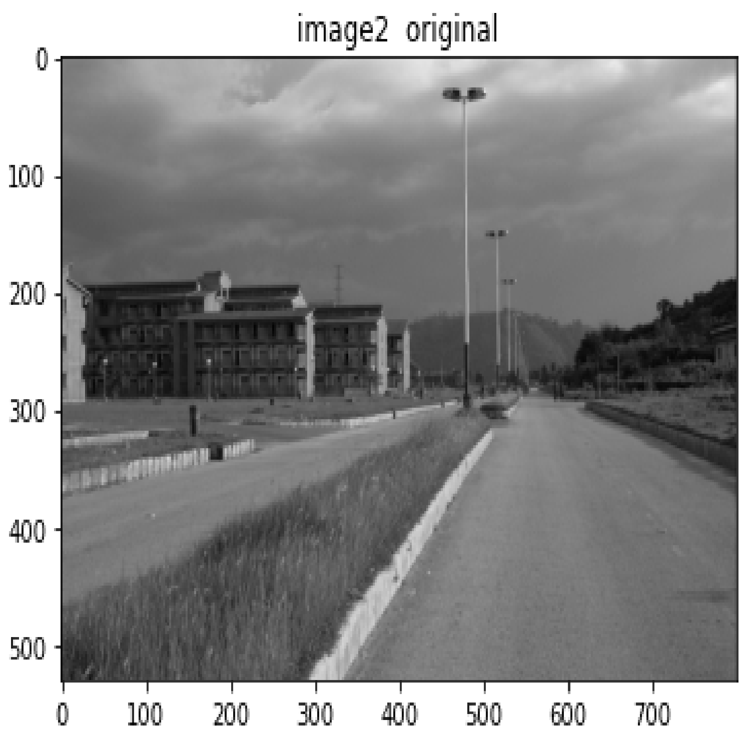


Figure 4: input image 2

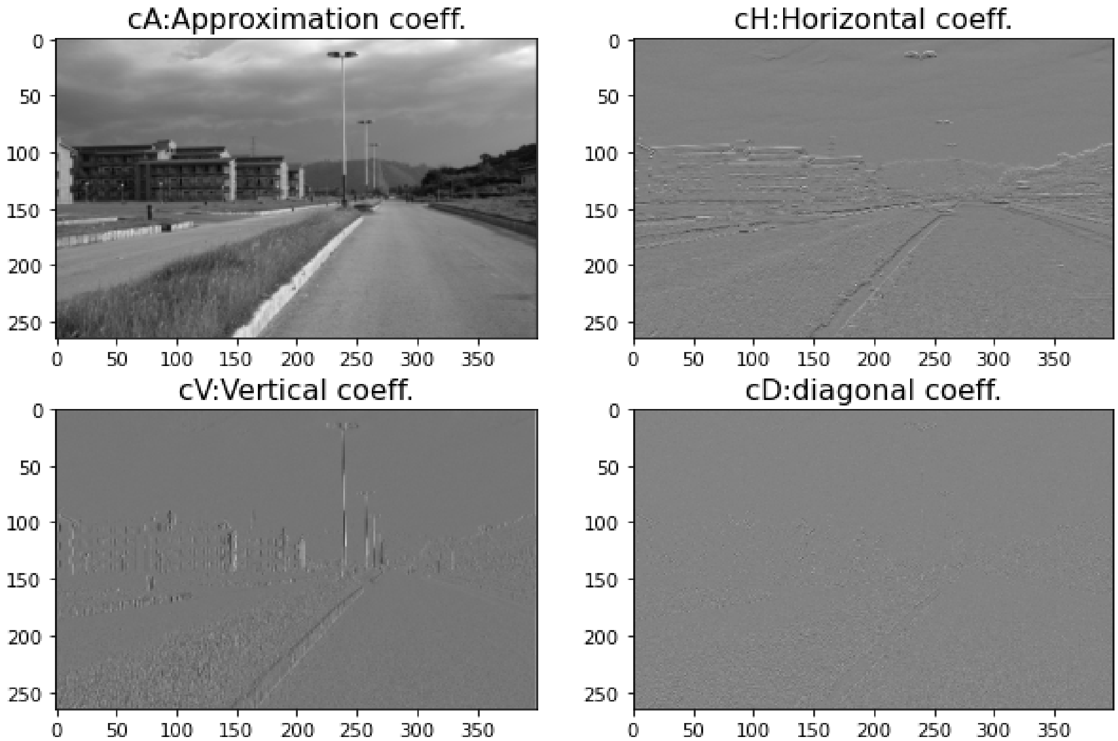


Figure 5: De-composition of image

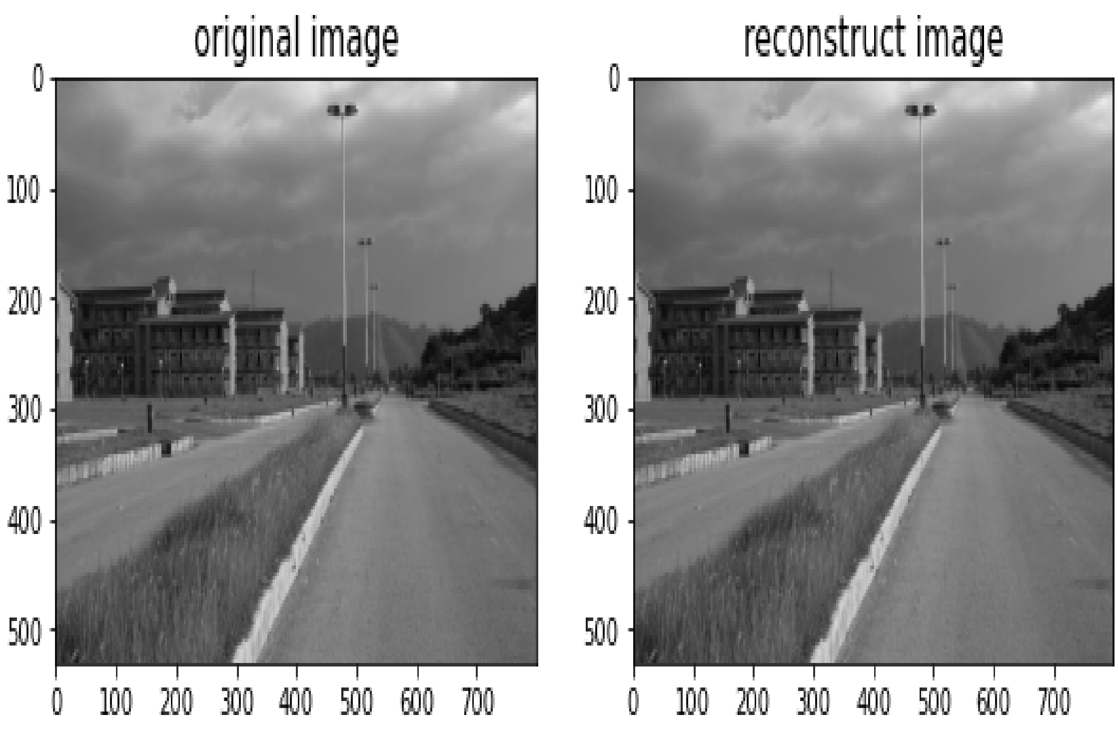


Figure 6: original image and reconstruct image

Table 1: MSE,PSNR,SSIM of output images of DCT technique

Image name	SSIM	PSNR	MSE
Lena	0.998	55.428268 db	0.18632
IIG	0.995	55.654738 db	0.17685

Table 2: Energy comparsion of original and reconstruction image

Image name	Energy of original image	Energy of Approx. component	energy of cH,cV,cD
Lena	18271.300997 joule	18231.298505 joule	40.002492 joule
IIG	13810.813142 joule	13782.971813 joule	45.031447 joule

4.2 Discrete Cosine Transform (DCT)

Several techniques can transform an image into frequency domain, such as DCT, DFT and wavelet transform. Each transform has its advantages. Discrete cosine transform (DCT) is widely used in image processing, especially for compression algorithm for encoding and decoding in DCT technique is shown below.

$$Y[k] = C[k] \sum_{n=1}^{N-1} X[n] \cos \frac{(2n+1)k\pi}{2N} \tag{3}$$

For k= 0,1,2,. . . ,N 1. Similarly, the inverse DCT transformation is defined as

$$X[n] = \sum_{k=0}^{N-1} C[k]Y[k] \cos \frac{(2n+1)k\pi}{2N} \tag{4}$$

For k= 0,1,2,. . . ,N 1 . In both equations (1) and (2) C[n] is defined as

$$C[n] = \left\{ \begin{array}{ll} \sqrt{\frac{1}{N}} & n = 0 \\ \sqrt{\frac{2}{N}} & n = 1, 2, ...N - 1 \end{array} \right\} \tag{5}$$

The 2-D DCT is a direct extension of the 1-D case and is given by:

$$y[j,k] = C[j]C[k] \sum_{m=0}^{N-1} \sum_{n=1}^{N-1} x[m,n] \cos \frac{(2m+1)j\pi}{2N} \cos \frac{(2n+1)k\pi}{2N} \tag{6}$$

Where: j, k = 0,1,2,. . . ,N 1 and. The inverse transform is defined as:

$$x[m,n] = \sum_{j=0}^{N-1}\sum_{k=1}^{N-1} C[j]C[k]y[j,k]\cos\frac{(2m+1)j\pi}{2N}\cos\frac{(2n+1)k\pi}{2N} \tag{7}$$

Where m, n = 0, 1, 2, . . . , N 1. And c[n] is as it is as in 1-D transformation

(a)Encoding: There are four steps in DCT technique to encode or compress the image

1. The image is broken into N*N blocks of pixels. Here N may be 4, 8, 16,etc.
2. Working from left to right, top to bottom, the DCT is applied to each block.
3. Each block's elements are compressed through quantization means dividing by some specific value.
4. The array of compressed blocks that constitute the image is stored in a drastically reduced amount of space.

(b) Decoding System: Decoding system is the exact reverse process of encoding. There are four steps for getting the original image not exact but identical to original from compressed image.

1. Load compressed image from disk.
2. Image is broken into N*N blocks of pixels.
3. Each block is de-quantized by applying reverse process of quantization.
4. Now apply inverse DCT on each block. And combine these blocks into an image which is identical to the original image.

Table 3: MSE,PSNR,SSIM of output images of DCT technique

Image name	SSIM	PSNR	MSE
Lena	1.0	314.435503 db	2.3416935378057303e-27
IIG	1.0	312.224706 db	3.895917375900613e-27

Table 4: Energy comparsion of original and reconstruction image

Image name	Energy of original image	Energy of reconstruct image
Lena	18271.300997 joule	18271.300997 joule
IIG	13810.813142 joule	13810.813142 joule

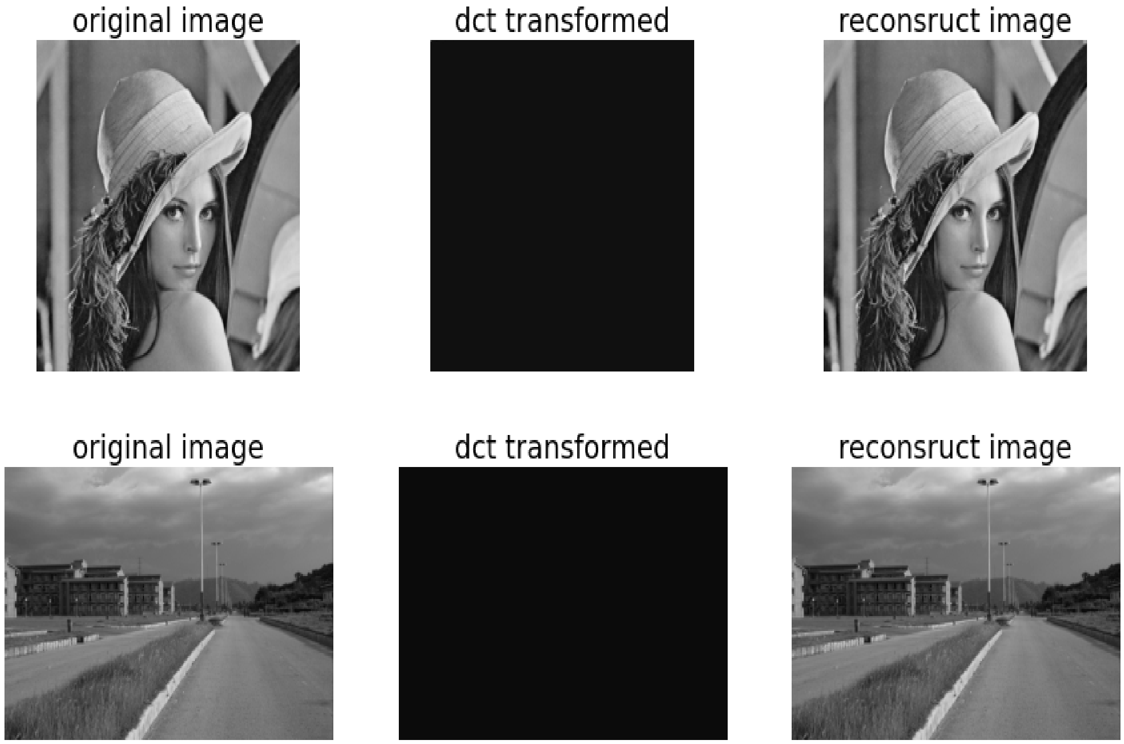


Figure 7: DCT Transform on images

5 Conclusion

By doing these experiments we conclude that both techniques have its' own advantage and disadvantage. But, both techniques are quite efficient for image compression. We can get quite reasonable compression ratio without loss of much important information.In this comparison we observe that mean square error is very less in DCT compare to Haar transform. We also observe that Structural Similarity Index (SSIM) is one in the DCT and both transform retain it's energy.

6 Reference

(1)https://www.sciencedirect.com/topics/computer-science/haar-transform
(2)https://core.ac.uk/download/pdf/234676913.pdf
(3)https://www.math.cuhk.edu.hk/~lmlui/dct.pdf