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# Efficient Hybrid Image Compression Scheme Using DWT and Quantization with DCT for Still Digital Image

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**Abstract:**
The increasing demand of multimedia content like digital images and videos has a great interest in research in compression techniques. The algorithm for higher quality and less expensive image acquisition device has produce steady increase in both image size and resolution. As we know the storage capacity and transfer bandwidth has grown accordingly in recent years, many applications still require compression. Image compression reduces the storage space of image and also maintains the quality of image. The essential information is extracted by various transforms techniques such that it can be reconstructed without losing quality and information of the image. . In this paper we will discuss the necessity of hybrid coding over classical coding schemes and why DCT – DWT hybrid approach is so important among various hybrid schemes. The goal is to achieve higher PSNR i.e. peak signal to noise ratio where original image means signal and the noise is error in reconstructed image.

**Keywords:** DCT, DWT, compression technique, hybrid transform, PSNR.

## I.INTRODUCTION

Image compression is important for many applications that involve huge data storage, transmission and retrieval such as for multimedia, documents, videoconferencing, and medical imaging. Uncompressed images require considerable storage capacity and transmission bandwidth. The objective of image compression technique is to reduce redundancy of the image data in order to be able to store or transmit data in an efficient form. This results in the reduction of file size and allows more images to be stored in a given amount of disk or memory space In digital image compression, three basic data redundancies can be identified and exploited:
(a) Coding redundancy
(b) Inter pixel redundancy
(c) Psycho visual redundancy. Redundancies are reduced or eliminated. Coding redundancy is present when less than optimal code words are used. Inter pixel redundancy results from correlations between the pixels of an image. Psycho visual redundancy is due to data that is ignored by the human visual system (i.e. visually non essential information). Image compression techniques reduce the number of bits required to represent an image by taking advantage of these redundancies.

### 1.1 Data compression techniques are:

(a) Lossless data compression - Lossless data compression is nothing but original data can be reconstructed exactly from compressed data.
(b) Lossy data compression – Lossy data compression in which data after compression and then decompression retrieves a file that is not exactly as the original data as there will be loss of data.

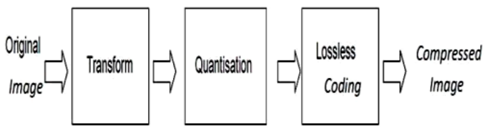


**Figure.1. Image compression model**

### 1.2 Error Matrices

For comparing various image compression techniques two error matrices i.e. Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR). MSE is cumulative squared error between the compressed and original image and PSNR is measure of peak error. If we find a compression technique having lower MSE and a high PSNR. We can recognize that it is much near about desired result.[5]

$$MSE = \frac{1}{MN} \sum_{Y=1}^{M} \sum_{x=1}^{N} [I(x,y) - I'(x,y)]^2 \quad (1)$$

$$PSNR = 20 * \log 10 (255 / \text{sqrt}(MSE)) \quad (2)$$

Where I(x,y) is the original image, I'(x,y) is the approximated version (which is actually the decompressed image) and M,N are the dimensions of the images. A lower value for MSE means lesser error, and as seen from the inverse relation between the MSE and PSNR, this translates to a high value of PSNR. Logically, a higher value of PSNR is good because it means that the ratio of Signal to Noise is higher. Here, the 'signal' is the original image, and the 'noise' is the error in reconstruction. So, if you find a compression scheme having a lower MSE (and a high PSNR), you can recognize that it is a better one.

### 1.3 Requirement for image compression system

An image compression system requires the following two components:
a. Encoding System
b. Decoding System
Encoding System takes original image as an input, processes it and gives compressed image as an output. While Decoding System takes a compressed image as input and gives the image as output which is more identical to original image. Nowadays, there are various compression techniques available. Discrete Cosine Transform (DCT) is one of the widely used image compression method and the Discrete Wavelet Transform (DWT) is another which provides improvements in the quality of the picture. This research paper proposed a scheme for

image compression using DCT and DWT named as hybrid compression technique. DCT has high energy compaction property and often require less computational resources and DWT is multi-resolution transformation. The goal is to achieve higher compression rates with preserving the quality of the reconstructed image.

**I. Discrete Cosine Transform-** The discrete cosine transform (DCT) represents an image as a sum of sinusoids of varying magnitudes and frequencies. The DCT has the property that, for a typical image, most of the visually significant information about the image is concentrated in just a few coefficients of the DCT. The DCT works by separating images into the parts of different frequencies. During a step called Quantization, where parts of Compression actually occur, the less important frequencies are discarded, hence the use of the lossy. Then the most important frequencies that remain are used retrieve the image in decomposition process. As a result, reconstructed image is distorted. DCT has many advantages:

(1) It has the ability to pack most information in fewest coefficients.

(2) It minimizes the block like appearance called blocking artifact that results when boundaries between sub-images become visible [4]

An image is represented as a two dimensional matrix, 2-D DCT is used to compute the DCT Coefficients of an image. The 2-D DCT for an NXN input sequence can be defined as follows

$$D(i,j) = \frac{1}{\sqrt{2N}} B(i)\, B(j) \sum_{x=0}^{N-1} . \sum_{y=0}^{N-1} . P(x,y) \quad (3)$$

$$\text{Cos}\left(\frac{(2X+1)i\pi}{2N}\right) \text{Cos}\left(\frac{(2y+1)i\pi}{2N}\right)$$

Where,

P(x, y) is an input matrix image NxN, (x, y) are the coordinate of matrix elements and (i, j) are the coordinate of coefficients, and

Where

$$B(u) = \begin{cases} \frac{1}{\sqrt{2}} & if\ u = 0 \\ 1 & if\ u > 0 \end{cases} \quad (4)$$

The reconstructed image is computed by using the inverse DCT (IDCT) according to

$$P(x,y) = \frac{1}{\sqrt{2N}} \sum_{i=0}^{N-1} . \sum_{j=0}^{N-1} B(i)\, B(j) . D(i,j) \quad (5)$$

$$\text{Cos}\left(\frac{(2X+1)i\pi}{2N}\right) \text{Cos}\left(\frac{(2y+1)i\pi}{2N}\right)$$

As we know the range of pixels from 0 to 255 of black and white images where 0 corresponds to a pure black and 255 corresponds to pure white and DCT is designed to work on pixel values ranging from -128 to 127, the original black is leveled off by 128 from every entry .The procedure of compression using DCT is given step by step and getting reconstructed image from compressed image can be illustrated in fig 2

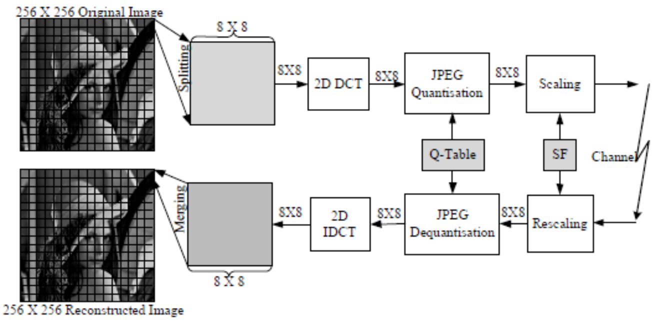


**Figure.2. DCT model**

**Encoding Technique in DCT*:*** Steps to encode or compress the image:-

**Step1.** Firstly the image is broken into N*N blocks of pixels. Here N may be 4, 8 etc.

**Step2.** Working from top to bottom, left to right, the DCT is applied to each block.

**Step3.** Every block elements are compressed through quantization means dividing by some specific value.

**Step4.** This array of compressed blocks that constitute the image is stored in a reduced amount of space. So, first the whole image is divided into small N*N blocks and then DCT is applied on these blocks. After that for reducing the storage space DCT coefficients are quantized through dividing by some value or by quantization matrix. So that large value become small and need small size of space. This step is lossy step. If we take small value for quantization then we get the better quality or less MSE (Mean Square Error) but less compression ratio [9]. Block size also affects quality and compression ratio. Simply, higher the block size higher is the compression ratio but with loss of more information and quality. Loss of information is measured by Mean square Error (MSE) between reconstructed image and original image. If MSE of the reconstructed image to original image is greater, than the information lost is more. As the number of coefficients increases quality of the image decreases whereas compression ratio continues to increase [10].

## II. DISCRETE WAVELET TRANSFORM

In this technique the image is decomposed into coefficients known as sub-bands and these coefficients are then compared with the threshold coefficients and the coefficients below threshold are set to zero. Finally, the coefficients above the threshold value are encoded with a loss less compression technique. The compression features of a given wavelet basis are primarily linked to the relative scarceness of the wavelet domain representation for the signal. The notion behind compression is based on the concept that the regular signal component can be accurately approximated using the following elements: a small number of approximation coefficients (at a suitably chosen level) and some of the detail coefficients.

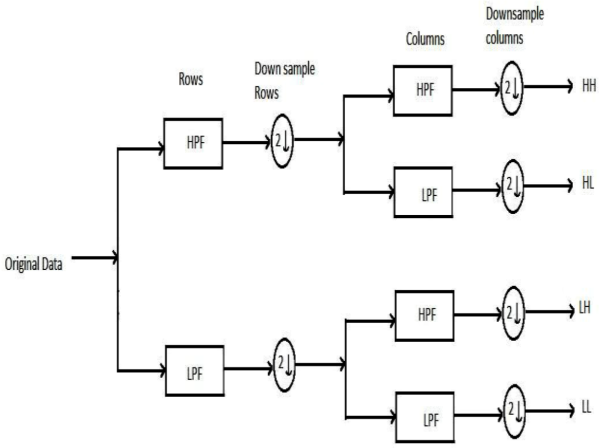


**Figure.3. Block diagram of 2-D forward DWT**

**Encoding technique in DWT**

There are six steps for compressing an image with DWT as shown below.

**Step1.** Firstly, the original image is passed through high pass filter and low pass filter by applying filter on each row.
**Step2.** Then output of the both image L1 and H1 are combined into T1= [L1 H1].
**Step3.** Then T1 is down sampled by 2.
**Step4.** Now, T1 is again passed through high pass filter and low pass filter by applying filter on each column.
**Step5.** Output of step 4 is supposed to be L2 and H2. Then L2 and H2 are combined into T3=[L2 H2].
**Step6.** Now T3 is down sample by 2. This is our compressed image [5].

## III. PROPOSED DCT- DWT HYBRID

The proposed hybrid algorithm is based on pixel transformation methods, DWT and DCT, a unique packet partition stage based on the high cross-correlation characteristic between adjacent elemental images, followed by quantization and entropy coding. The block diagram of the encoder and decoder of the proposed hybrid compression scheme is shown in Fig. 4. The decoder reconstructs the image by inverting the steps of the encoder [7].

### Coding scheme

### (a) Compression procedure

The input image is first converted to gray image from color image, after this whole image is divided into size of 32x32 pixels blocks. Then 2D-DWT applied on each block of 32x32 blocks, by applying 2 DDWT, four details are produced. Out of four sub band details, approximation detail/sub band is further transformed again by 2 D-DWT which gives another four sub-bands of 16x16 blocks. Above step is followed to decompose the 16x16 block of approximated detail to get new set of four sub band/details of size 8x8. The level of decomposition is depend on size processing block obtained initially, i.e. here we are dividing image initially into size of 32x32, hence the level of decomposition is 2. After getting four blocks of size 8x8, we use the approximated details for computation of discrete cosine transform coefficients. These coefficients are then quantize and send for coding. [6]

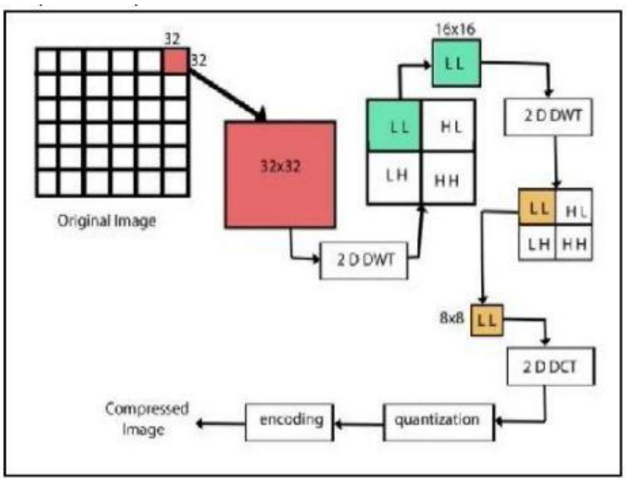


**Figure.4. Compression technique using Hybrid transform**

### (b)Decompression procedure

At receiver side, we decode the quantized DCT coefficients and compute the inverse two dimensional DCT (IDCT) of each block. Then block is dequantized. Further we take inverse wavelet transform of the dequantized block. Since the level of decomposition while compressing was two, we take inverse wavelet transform two times to get the same block size i.e. 32x32. This procedure followed for each block received. When all received blocks are converted to 32x32 by following decompression procedure, explained above. We arrange all blocks to get reconstructed image. The complete coding and decoding procedure is explained in Figure respectively. [6]

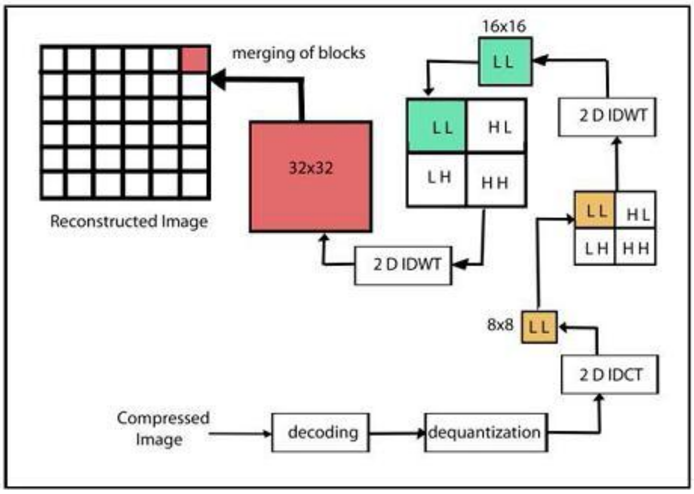


**Figure.5. Decompression technique using Hybrid transform**


**Table .1.**

| Image<br>**Boat.jpg** | Technique | Compression Ratio | MSE | PSNR |
|---|---|---|---|---|
| 512x512 | DCT | 25.6737 | 2.673 | 42.738 |
| | DWT | 28.6738 | 30.2783 | 32.738 |
| | HYBRID | 59.5782 | 0.012 | 68.0392 |

## IV. COMPARATIVE ANALYSIS AND RESULTS

For analysis of different image compression techniques codes of DCT, DWT and Hybrid were written in Matlab and results obtained are shown in table 1. The results are obtained for images of size 512 x 512.Fromtable 1 we can see that compression ratio is high for hybrid transform as compare to other transform technique.DWT adds noise to the image for improvement in the reconstructed image DCT gives less compression ratio but it is efficient as compared to other techniques.

## V. CONCLUSION

In this paper comparative analysis of various Image compression techniques for different images is done based on three parameters compression ratio(CR), mean square error (MSE), peak signal to noise ratio (PSNR). Our results show that we can achieve higher compression ratio using Hybrid technique but loss of information is more. DWT gives better compression ratio without losing more information of image.

Pitfall of DWT is, it requires more processing power. DCT overcomes this disadvantage since it needs less processing power, but it gives less compression ratio. DCT based standard JPEG uses blocks of image, but there are still correlation exits across blocks. Block boundaries are noticeable in some cases. Blocking artifacts can be seen at low bit rates. In wavelet, there is no need to block the image. More robust under transmission errors. It facilitates progressive transmission of the image (scalability). Hybrid transform gives higher compression ratio but for getting that clarity of the image is partially trade off. It is more suitable for regular applications as it is having a good compression ratio along with preserving most of the information.

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