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Comparison of the Performance of Image Compression Techniques on Different Categories of Images

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***Abstract*— Digital images in their uncompressed form require a huge amount of storage capacity. Such uncompressed data desires large transmission bandwidth for the transmission over the network. Many compression standards are in place. Two most popular methods are DCT and DWT. The JPEG standard makes use of Discrete Cosine Transform (DCT) for compression. The other is based on wavelets. This paper aims at the analysis of compression using DCT and Wavelet transform by selecting proper threshold scheme we can get better result for PSNR have been obtained.**

***Keywords*— DCT, DWT, Hybrid, Lossy and Lossless.**

I. INTRODUCTION

We know that a large amount of data and information internet is in the form of image. Image in its uncompressed form necessitate huge storage space and it also require huge transmission bandwidth for transmission over network. That's why it is significant to have image compression techniques. The objective of image compression is to reduce redundancy and irrelevance of the image in order to be able to store and transmit in an efficient form. There are several methods for image compression. They are mainly categorized into two categories- Lossless compression and lossy compression [1]. In a lossless compression algorithm, compressed data can be used to recreate an exact replica of the original; no information is lost to the compression process. Lossless image compression is particularly useful in image archiving as in the storage of legal or medical records. In lossy compression, the original signal cannot be exactly reconstructed from the compressed data; reason is that lots of the information has been discarded for image compression. In lossy image compression, although very fine details of the images are lost, but image size is drastically reduced [2]. This is useful for those applications where low storage space and fast data transmission speed is required. JPEGE described a method for image compression which is a known form of lossy image compression which on based on discrete cosine transform. This is the most widely used form of image compression. 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. Another method for image compression is DWT (Discrete Wavelet Transform). In DWT, an image is represented by sum of wavelet functions, which are known as wavelets. Image is transformed and compressed as a single data object rather than block by block [1], [3]. It achieve better image quality and compression ratio.

II. DISCRETE COSINE TRANSFORM

As it is a lossy image compression technique. Compression is achieved by losing some information while maintaining image quality. Hence, the image cannot reconstruct exactly as the original one. DCT separates the image into two parts of different frequencies where less important frequencies are discarded through quantization and important frequencies are retrieve the image during reconstruction. A DCT represents the input data points in the form of a sum of cosine functions that are oscillating at different frequencies and magnitudes [4]. There are primarily two types of DCT: one dimensional (1-D) DCT and two dimensional (2-D) DCT. Since an image is represented as a two dimensional matrix, for this research work, 2-D DCT is considered. The 2-D DCT for an NXN input sequence can be defined as follows [2, 5]:-

$$D_{DCT}(i,j)=\frac{1}{\sqrt{2N}} B(i)\, B(j) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} M(x,y) \cos\left[\frac{2x+1}{2N} i\pi\right] \cos\left[\frac{2y+1}{2N} j\pi\right]$$

Where,

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

M(x, y) is the input data of size x X y

Process

1. Original image is divided into blocks of 8 x 8.
2. Pixel values of a black and white image range from 0-255 but DCT is designed to work on Pixel values ranging from -128 to 127. Therefore each block is modified to work in the range.
3. Equation is used to calculate DCT matrix.

4. DCT is applied to each block by multiplying the modified block with DCT matrix on the left and transpose of DCT matrix on its right.
5. Each block is then compressed through quantization.
6. Quantized matrix is then entropy encoded.
7. Compressed image is reconstructed through reverse process.
8. Inverse DCT is used for decompression**.**

Quantization

The compression takes place at the stage of quantization. It enables the user to decide quality and compression which range from 1 to 100. 1 gives poorest image quality and highest compression while 100 gives the best quality and poorest compression [6]. Quantization is achieved by matrix by corresponding element of the quantization matrix and then rounding the nearest value.

Entropy encoding

After quantization final step of compression is applied. Before storage all the coefficient of quantization matrix is converted by an encoder to a stream of binary data. After quantization it is quite common for most of the coefficient equals to zero. JPEG takes advantage of this by encoding quantized coefficient in a zig-zag manner [1],[6].

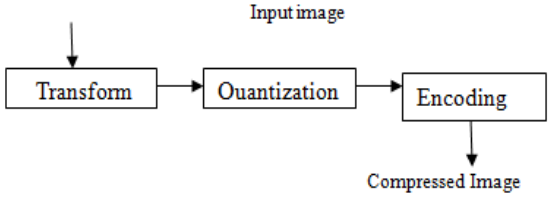


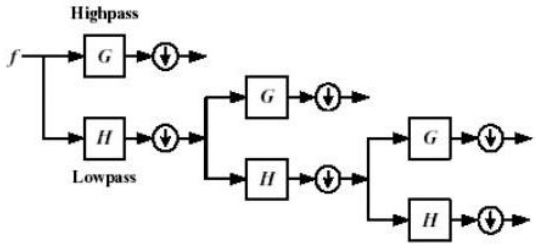
Image Compression Model

III. DISCRETE WAVELET TRANSFORM

In DWT an image is represented as the sum of wavelet functions known as wavelets. Wavelet based coding provides significant improvement in picture quality at high compression ratios mainly due to better energy compaction property of wavelet transforms [6]. Wavelet transform partitions a signal into a set of functions called wavelets. A signal is passed through a series of filters to calculate DWT [8]. The procedure of DWT starts by passing this signal sequence through a half band digital low pass filter. A half band low pass filter removes all frequencies that are above half of the highest frequency in the tile signal. Then the signal is passed through high pass filter. The two filters are related to each other as

$h[L-1-n]=(-1)^n g(n)$

Filters satisfying above condition are known as quadrature mirror filters [7]. After filtering half of the samples can be eliminated since the signal now has the highest frequency as half of the original frequency. The signal can therefore be subsampled by 2, simply by discarding every other sample.



This decomposition halves the time resolution since only half the number of sample now characterizes the whole signal. Frequency resolution has doubled because each output has half the frequency band of the input. This process is called as sub band coding.

Steps for compression

1. Digitize the source image into a signal s, which is a string of numbers.
2. Decompose the signal into a sequence of wavelet coefficients w.
3. Use threshold to modify the wavelet coefficients from w to w'.
4. Use quantization to convert w' to a sequence q.
5. Entropy encoding is applied to convert q into a sequence.

Digitalization

The image is first digitized. The digitized image can be represented by its intensity levels, or scales of gray which range from 0(black) to 255(white), and its resolution, or how many pixels per square inch.

Threshold in Wavelet Compression

For some signals, many of the wavelet coefficients are close to or equal to zero. Threshold can modify the coefficients to produce more zeros. In Hard threshold any coefficient below a threshold λ, is set to zero. This should then produce many consecutive zero's which can be stored in much less space, and transmitted more quickly by using entropy coding compression.

Quantization

The simplest form is to round to the nearest integer. Quantization is called lossy because it introduces error into the process, since the conversion of w' to q is not one to one function.

Entropy Encoding

The integer q is coded to make it shorter sequence.

Reconstruction

For data reconstruction, the coefficients are rescaled and padded with zeros, and passed through the wavelet filters. In order to reconstruct the image.

In this paper both techniques are used in a hybrid manner. Firstly, DCT is applied on the input image, which divides the image into blocks of 8x8. Then DWT is applied on this block. This process is looped for the whole image. Hybrid technique has advantages of both technique DCT and DWT.

IV. RESULT

Test has been applied on four categories of data: human, animal, nature and sea in order to compare DCT and Hybrid DCT-DWT.Fig.1 showing the graph of image compression performance of the two techniques namely hybrid DCT-DWT and DCT. Result has been obtained from hundred images, twenty five image of each category. A table is also derived from the resultant data which shows the average of size of compressed images of four categories.

Table 1.1 shows comparison of image size of the images of different categories. This table clearly shows that hybrid technique reduces the size of image up to great extend.

Another parameter is PSNR which shows the quality of image. T1.2 shows the comparison of PSNR of images, PSNR of images compressed with hybrid technique is lower than that of DCT. Hence in hybrid technique quality of image is maintained.

T1.3 shows the images with different compression techniques and their respective compression parameter.

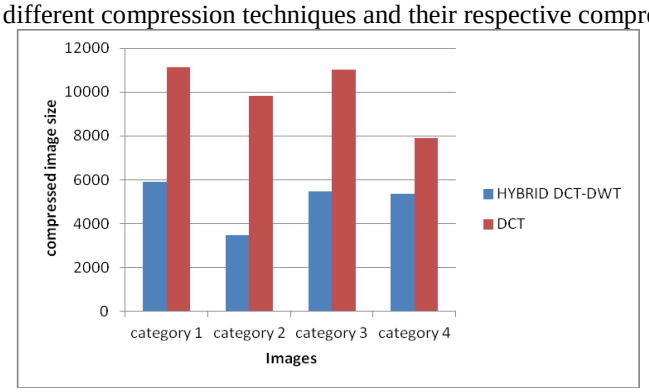


Fig: 1.1 size of compressed images

Image Name	Original size	Hybrid DCT-DWT	DCT
human5	7017	6735	6345
human9	6830	5301	6237
animal4	8800	7236	8211
animal12	10761	10256	10814
nature22	7925	7546	7215
nature25	9548	8824	8953
sea24	7953	7826	7894
sea25	10256	10114	10100

T 1.1 comparison of image size of images of different category

Image Name	Hybrid DCT-DWT	DCT
human5	24.0277	47.1337
human9	24.7788	52.1261
animal4	27.3591	51.3315
animal12	35.6321	54.9285
nature22	21.3256	44.2156
nature25	29.2341	45.3219
sea24	24.3286	51.8532
sea25	26.8756	47.3698

T1.2 Comparison of PSNR

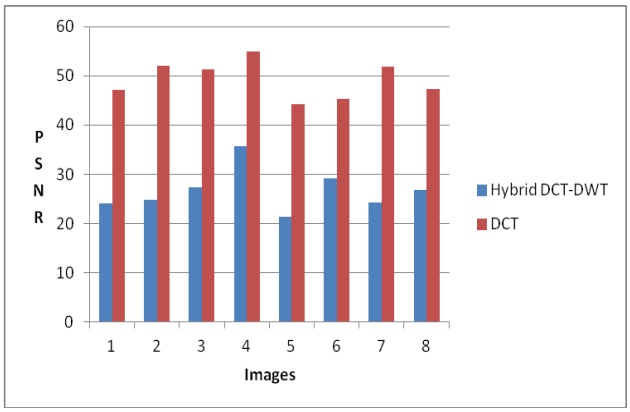
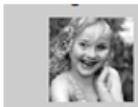


Fig 1.2 comparison of PSNR

Image	Image size in bytes	PSNR
Original image 	9973	-
Hybrid DCT-DWT 	9195	24.549
DCT 	9395	54.919

T 1.3 Comparison of Image

V. CONCLUSION

In the thesis image compression techniques using DCT and DWT were implemented. DCT is used for transformation in JPEG standard. DCT performs efficiently at medium bit rates. Disadvantage with DCT is that only spatial correlation of the pixels in-side the single 2-D block is considered and the correlation from the pixels of the neighboring blocks is neglected. Blocks cannot be decorrelated at their boundaries using DCT. DWT is used as basis for transformation in JPEG 2000 standard. DWT provides high quality compression at low bit rates. The use of larger DWT basis functions or wavelet filters produces blurring near edges in images. DWT performs better than DCT in the context that it avoids blocking artifacts which degrade reconstructed images. However DWT provides lower quality than JPEG at low compression rates.DWT requires longer compression time. By using both the techniques in hybrid, advantage of both the techniques can be taken. Images compressed with hybrid technique have good compression ratio and PSNR.

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