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Performance Analysis of Discrete Cosine Transform and Discrete Wavelet Transform for Image Compression

[1]K. Hemachandran and [2]B. Justus Rabi
[1]ECE Visvesvaraya College of Engineering and Technology, Hyderabad, India
[2]Shri Andal Alagar College of Engineering, Maamandur, Chennai, India

Abstract: To reduce the size of the image to store more images in the memory or disk and to reduce the transmit time for sending the images over the internet or to download from internet image compression techniques are used. With the growth of technology and entrance into the digital age, the world has found itself in the middle of a enormous amount of information. Dealing with such enormous information can often present difficulties. Image compression is decreasing the size in bytes of a graphics file without reducing the quality of the image to an unacceptable level. In this study, a comparison was made between Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT). The discrete cosine transform is a fast transform. It has excellent compaction for highly correlated data. DCT has fixed basis images DCT gives good compromise between information packing ability and computational complexity. Whereas DWT can also be used to reduce the image size without losing much of the resolutions computed and values less than a pre-specified threshold are discarded. Thus, it reduces the amount of memory required to represent given image. Comparing the efficiency of the technique DWT is preeminent in image compression.

Key words: Discrete cosine transform, discrete wavelet transform, image compression, JPEG, signal noise ratio, efficiency

INTRODUCTION

Image compression is employed to cut back the image dimension and redundancy of the image information. The number of data accustomed represent these image thus has to be reduced. Compression deals with redundancy, the amount of bits required to characterize on image by removing redundant data. Decreasing the redundancy is that the main aim of the compression technique. compression technique, largely used 2 Dimensional (2D) compression standards such us JPEG or JPRG2000 usually contemplate only intra brand correlation (Gonzalez *et al*., 2004) compression is generally classified into two classes particularly lossy and lossless depending on whether or not the original image is recovered with fill mathematic exactitude from the compressed image. Compression is that the better of digital image process. Lossless or lossy compression approaches is applied to hyper spectral image. Lossy compression is based on the principle of removing subjective redundancy. Lossless compression is based on effective signal noise ratio (Pantaesaena *et al*., 2005).

Original image can be fully recovered in lossless image compression. It is useful to build the significant transforms for the lossless image compression area including dwt and various color space transforms. Nowaday, the high compression was established in lossy compression technique is JPEG2000. This is a high performance in compression technique developed by the Joint Graphic Experts Group Committee (Pantaesaena *et al*., 2005). The high compression was established in lossy finds the highest Peak Signal Ratio (PSNR) and compression magnitude relation. Compression ratio of PSNR values between the same set of images at very low bit rates. It can be observed that Lena image, Barbara image, Peppers Gold hill. This image performance may be calculated using DCT and DWT algorithms. The input image is divided in to n×n blocks. Then, each block is transformed using DCT and DWT. The DCT coefficients of each block is arranged in hierarchical manner. DWT have different types of wavelets and thresholding techniques. The first step of the compression algorithm is image decomposition in nxn sub images. The DWT coefficients of each block is arranged in Hilbert fractal curve (Watson, 1994). The wavelet transforms is applied to every vector and a few of the high frequency are suppressed supported the some threshold criteria.

Wavelet transforms involve representing a general purpose in terms of easy, fastened building blocks are

Corresponding Author: K. Hemachandran, ECE Visvesvaraya College of Engineering and Technology, Hyderabad, India

generated from a specific fastened perform referred to as mother wavelet perform. DCT solely compress the image of lower decorative performance, DCT is low level compression. DCT solely offers lossy transform. DWT offers each lossy and lossless transform. The most focus of this work is dwt filter supported achieved compression ratio. The planned compression technique has been tested on well-known image like compared with the JPEG2000 and DWT techniques (Gonzalez *et al*., 2004). At finally lossless compression DWT is followed.

MATERIALS AND METHODS

Image compression using DCT: JPEG stands for the joint photographic experts group, a standards committee that had its origins within the International Standard Organization (ISO). JPEG provides a compression methodology that is capable of compressing continuous-tone image information with a pel depth of 6-24 bits with reasonable speed and potency. JPEG could also be adjusted to provide terribly tiny, compressed images that are of comparatively poor quality in look, however, still appropriate for several applications (Ahmed *et al*., 1974; Ames, 2002). Conversely, JPEG is capable of manufacturing terribly high-quality compressed pictures that area unit still way smaller than the initial uncompressed knowledge.

JPEG is primarily a lossy methodology of compression. JPEG was designed specifically to discard information that the human eye cannot simply see. Slight changes in color aren't perceived well by the human eye, whereas slight changes in intensity (light and dark) are. So, JPEG's lossy encoding tends to be a lot of economical with the gray-scale a part of a picture and to be a lot of trivial with the color. DCT separates pictures into components of various frequencies wherever lesser frequencies are discarded through division and vital frequencies are accustomed retrieve the image throughout decompression. Compared to different input dependent transforms, DCT has several advantages: it's been enforced in single integrated circuit; it's the power to pack most data in fewest coefficients; it minimizes the block like look referred to as blocking whole thing that results once boundaries between sub-images become visible (Mallat, 1989). The forward 2D_DCT transformation is given by the subsequent (Eq. 1):

$$C(u, v) = D(u)D(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x, y) \cos\left[\frac{(2x+1)u\pi}{2N}\right]\cos\left[\frac{(2y+1)v\pi}{2N}\right] \quad (1)$$

where, u, v = 0, 1, 2, 3, ..., N-1. The inverse 2D-DCT transformation is given by the subsequent (Eq. 2):

$$f(x, y) = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} D(u)D(v)D(u, v) \cos\left[\frac{(2x+1)u\pi}{2N}\right]\cos\left[\frac{(2y+1)v\pi}{2N}\right] \quad (2)$$

Where:
D(u) = (1/N)^1/2 for u = 0
D(u) = (2/N)^1/2 for u = 1, 2, 3, ..., N-1

Please, leave two blank lines between successive sections as here. Mathematical equations must be numbered as follows: 1, 2, …, 99 and not 1.1, 1.2, …, 2.1, 2.2, …, depending on your various sections.

JPEG image process:

- Original image is divided into blocks of 8×8
- Pel values of a black and white image range from 0-255 but DCT is designed to work on pel values ranging from -128 to 127. Therefore, every block is modified to work in the range
- Equation 1 is used to calculate DCT matrix
- 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
- Each block is then compressed through quantization
- Quantized matrix is then entropy encoded
- Compressed image is reconstructed through reverse process (Mallat, 1989)
- Inverse DCT is used for decompression

Quantization: Quantization is achieved by compressing a spread of values to one quantum value. once the quantity of distinct symbols in a very given stream is reduced, the stream becomes additional compressible. A division matrix is employed together with a DCT constant matrix to hold out transformation. Quantization is that the step wherever most of the compression takes place. DCT very doesn't compress the image as a result of it's virtually lossless. Division make sure of the very fact that higher frequency elements are less significant than low frequency elements. It permits varied levels of compression and quality through choice of specific division matrices. Therefore, quality levels starting from one to a hundred are often selected , wherever one offers the poorest image quality and highest compression, whereas a hundred offers the simplest quality and lowest compression (De Vore *et al*., 1992). As a result quality to compression quantitative relation are often selected to fulfill totally different desires. JPEG committee suggests

Table 1: The elements within the numerical order

Codes	0	1	2	3	4	5	6	7
0	0	1	5	6	14	15	27	28
1	2	4	7	13	16	26	29	42
2	3	8	12	17	25	30	41	43
3	9	11	18	24	31	40	44	53
4	10	19	23	32	39	45	52	5
5	20	22	33	38	46	51	55	60

matrix with quality level fifty as standard matrix. For getting quantization matrices with alternative quality levels, scalar multiplications of standard quantization matrix are used. division is achieved by dividing remodeled image matrix by the division matrix used. Values of the resultant matrix are then rounded off. Within the resultant matrix coefficients situated near the higher left corner have lower frequencies (Ponomarenko *et al*., 2005). Human eye is more sensitive to lower frequencies. Higher frequencies are discarded. Lower frequencies are wont to reconstruct the image.

Entropy encoding: After quantization, most of the high frequency coefficients are zeros. to use the amount of zeros, a zig-zag scan of the matrix is employed yielding to long string of zeros. Once a block has been regenerate to a spectrum and quantity, the JPEG compression algorithmic rule then takes the result and converts it into a one dimensional linear array, or vector of sixty four values, playing a zig-zag scan by choosing the elements within the numerical order indicated by the numbers within the grid (Table 1).

This places the weather of the constant block during a reasonable order of increasing frequency. Since, the upper frequencies are a lot of possible to be zero when quantization, this tends to cluster zero values within the high finish of the vector.

Huffman cryptography: The basic plan in Huffman coding is to assign short code words to those input blocks with high chances and long code words to those with low chances (Ramesh and Rajgopal, 1990; Pantaesaena *et al*., 2005). A Huffman code is intended by merging along the two least probable characters and continuation this method till there's just one character remaining. A code tree is therefore generated and also the Huffman code is obtained from the labeling of the code tree.

Image compression using DWT: Wavelet primarily based coding provides substantial improvement in image quality at high compression ratios in the main due to higher energy compaction property of wavelet transforms.

Wavelets remodel partitions an indication into a collection of functions referred to as wavelets (Lewis and Knowles, 1992). Wavelets are obtained from one model

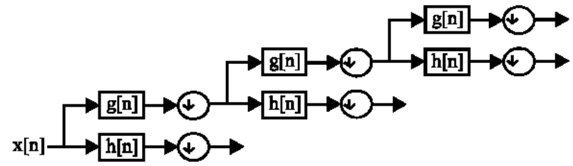

Fig. 1: Filter banks

wavelet referred to as mother wavelet by dilations and shifting. The wavelet remodel is computed severally for various segments of the time-domain signal at different frequencies.

Subband coding: A signal is gone through a series of filters to calculate DWT. Procedure starts by passing this signal sequence through a half band digital low pass filter with impulse response h(n). Filtering of a signal is numerically adequate convolution of the tile signal with impulse response of the filter:

$$x[n]*h[n] = \sum_{k=-\infty}^{\infty} x[k].h[n-k] \quad (3)$$

A half band low pass filter removes all frequencies that are higher than half of the very best frequency in the tile signal (Fig. 1). Then, the signal is gone through high pass filter. The two filters are associated with each other as:

$$h[L\text{-}1\text{-}n] = (\text{-}1)^n g(n) \quad (4)$$

Filters satisfying this condition are referred to as construction mirror filters. After filtering half of the samples are often eliminated since the signal currently has the very best frequency as half of the initial frequency. The signal will so be sub sampled by a pair of simply by discarding each different sample. This constitutes one level of decomposition and may mathematically be expressed as:

$$y1[n] = \sum_{k=-\infty}^{\infty} x[k]h[2n-k] \quad (5)$$

$$y2[n] = \sum_{k=-\infty}^{\infty} x[k]h[2n+1-k] \quad (6)$$

where, y1[n] and y2[n] are the outputs of low pass and high pass filters, respectively when sub sampling by 2. This decomposition halves the time resolution since solely half the amount of sample currently characterizes the full signal. Frequency resolution has doubled as a result of every output has half the waveband of the input (Antonini *et al*., 1992; Averbuch *et al*., 1996). This method is termed as sub band coding. It is often continual further to extend the frequency resolution as shown by the filter bank (Watson, 1994).

Compression steps:

- Digitize the source image into a signal s which is a string of numbers
- Decompose the signal into a sequence of wavelet coefficients w
- Use threshold to modify the wavelet coefficients from w to w'
- Use quantization to convert w' to a sequence q
- Entropy encoding is applied to convert q into a sequence e

Digitation: The image is digitized initial. The digitized image are often characterised by its intensity levels or scales of grey that vary from 0 (black) to 255 (white) and its resolution or what percentage pixels per square inch.

Thresholding: In bound signals, several of the wave coefficients are shut or up to zero. Through threshold these coefficients are changed so the sequence of wave coefficients contains long strings of zeros. In laborious threshold, a threshold is chosen. Any wave whose definite quantity falls below the tolerance is about to zero with the goal to introduce several zeros while not losing an excellent quantity of detail.

Quantization: Quantization converts a sequence of floating numbers w' to a sequence of integers q. The simplest type is to round to the closest integer. Another technique is to multiply every range in w' by a constant k, then spherical to the closest integer. Quantization is named lossy as a result of it introduces error into the method, since the conversion of w' to q isn't one to at least one function (Cabeen and Gent, 1998).

Entropy encoding: With this technique, a integer sequence q is modified into a shorter sequence e with the numbers in e being eight bit integers. The conversion is created by an entropy encryption table. Strings of zeros are coded by numbers one through one hundred, 105 and 106 while the non-zero integers in q are coded by a hundred and one through 104 and 107 through 254.

RESULTS AND DISCUSSION

For simulation, we apply DCT technique on three different images by choosing 8×8 block size. These three original images and output images are shown below. All three images have different size.

In Fig. 2, we can see the reconstructed image is not same as the input image. But all are identical to their input

Baby (1) Baby (2)

Penguins (3) Penguins (4)

Fig. 2: 1) Original baby image; 2) Compressed using DCT; 3) Original penguins image and 4) Compressed using DCT

Table 2: MSE output images of DCT technique

Image name	MSE	Total (MSE of original image with zero image)
Baby	10289294	2.11×10^{10}
Penguins	17012605	2.10×10^{10}

image. We can see that in compressed image of baby, there are block artifacts on her hand's picture. If we choose small size of block then the block artifacts is minimized. By using 8×8 block size and applying quantization we minimized the each pel value 0-32 from 0-256. So, one pel needs 5 bits to represent its value on behalf of 8 bits. Thus, we achieve Cr = 8/5 = 1.6 which is quite reasonable.

Table 2 shows MSE of each of two images. It shows how much information we have lost due to our compression technique. There is also shown total MSE of original image with zero images. So, we can analyze that how many percentage of the information we loss out of total information.

When we applied DWT to original image. The output images show that there is no any block artifacts. Because we apply DWT on whole image, not on block. We got Cr = 1.9-2.3 compression ratio (Fig. 3). MSE of reconstructed images are also less as shown in Table 3. For DCT technique we can achieve the Cr = 1.6 compression ratio. For DWT technique we can achieve the Cr = 1.9-2.3 compression ratio.

Figure 4 shows the comparison of lost of information in DCT and DWT technique. From this we conclude that

Fig. 3: 1) Original baby image; 2) Compressed using DWT; 3) Original penguins image and 4) Compressed using DWT

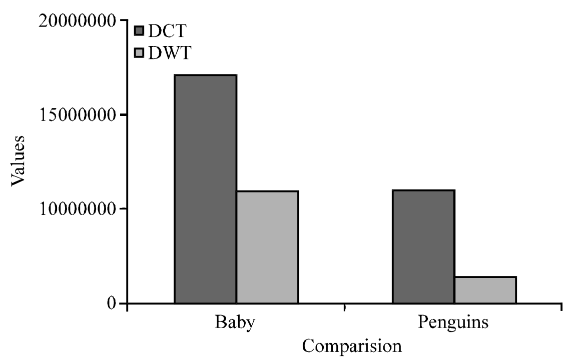

Fig. 4: Graph for comparing DCT, DWT information lose

Table 3: MSE output images of DWT technique

Image name	MSE	Total (MSE of original image with zero image)
Baby	1.36×10^{6}	2.11×10^{10}
Penguins	8.05×10^{6}	2.10×10^{10}

in DWT information loss is less than information loss in DCT. So, quality wise the DWT technique is better than DCT technique but in performance time wise DCT is better than DWT technique.

CONCLUSION

From these experiments we have a tendency to conclude that each methods have it's own benefit and Disadvantage. But, each techniques are quite economical for compression. we will get quite smart Compression ratio (Cr) while not loss of abundant necessary information. though our experiments show that DWT technique is far economical than DCT technique in quality and potency wise. However in performance time wise DCT is better than DWT.

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