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A Hybrid JPEG & JPEG 2000 Image Compression Scheme for Gray Images

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Abstract—Image compression method is trying to reduce number of bits per pixel for sufficient representation of image, so memory needed for storing necessary information is reduced and communication efficiency is upgraded. The goal of compression algorithms is to gain best compression ratio with acceptable visual quality, the proposed compression satisfy this goal. Transform with DCT (Discrete Cosine Transform) and DWT (Discrete Wavelet Transform) is most commonly used. DCT has high energy compaction property and requires less computational resources. On other hand, DWT multiresolution Transformation. In this paper, we propose a Hybrid DWT-DCT algorithm for image compression and reconstruction taking benefit from the advantages of both algorithms. The simulation results show that the proposed Hybrid DWT-DCT algorithm performs much better than standalone JPEG based DCT, and JPEG 2000 based DWT in terms of BPP (bits per pixel) and CR (compression ratio).

Keywords—Image compression, DCT, DWT, Hybrid (DWT+DCT)

I. Introduction

The main purpose of image compression is to reduce the redundancy and irrelevancy present in the image, so that it can be stored and transferred efficiently. The compressed image is represented by less number of bits compared to original. Hence, the required storage size will be reduced, consequently maximum images can be stored and it can transferred in faster way to save the time, transmission bandwidth.

The Joint Photographic Expert Group (JPEG) , based on the Discrete Cosine Transform (DCT). It has been one of the most widely used compression methods. Although 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 addition, the quality of the reconstructed images is degraded by the "false contouring" effect for specific images having gradually shaded areas. The Discrete Wavelet Transform (DWT) based coding, on the other hand, has been emerged as another efficient tool for image compression mainly due to its ability to display image at different resolutions and achieve higher compression ratio.

In lossless compression scheme, i.e. DWT the reconstructed image is identical to the original image. In Lossy compression scheme, i.e. DCT the reconstructed image contains degradation relative to the original.

In Lossy Compression causes image quality degradation in each compression or decompression step. In general, lossy techniques provide for greater compression ratios than lossless techniques i.e. Lossless compression gives good quality of compressed images, but yields only less compression whereas the lossy compression techniques lead to loss of data with higher compression ratio.

In this paper we made the comparative analysis of three transform coding technique, via, DCT , DWT , Hybrid DCT-DWT based on different performance measure such that Peak Signal to Noise ratio (PSNR), Bits Per Pixel (BPP), Compression Ratio (CR).

2. Discrete Cosine Transform

In Discrete Cosine Transform (DCT) an image converted into frequency component in which the higher frequency is discarded. For compression the image is divided into 8x8 blocks and the 2-D DCT is computed for each block. After that the DCT coefficients are then quantized, coded and transmitted.

$$|C|_{i,j} = \begin{cases} \sqrt{1/N}\cos\dfrac{(2j+1)i\pi}{2N} & i = 0,\ j = 0,1,...,\ N-1 \\ \sqrt{2/N}\cos\dfrac{(2j+1)i\pi}{2N} & i = 1,2,...,\ N-1,\ j = 0,1,..,\ N-1 \end{cases}$$

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 arti-facts that the results when boundaries between sub-images become visible.

DCT is primarily a lossy method of compression. It was de-signed specifically to discard the information that the human eye cannot easily see.

3. Discrete Wavelet Transform

Wavelet transform has emerged as very powerful tool for data compression. Wavelet transform performs multiresolution image analysis. Multiresolution means simultaneous representation of image on different resolution levels. Wavelet transform represent an image as a sum of wavelets functions, with different location and scales. In 2D, the images are considered to be matrices with N rows and M columns. In wavelet transform, decomposition of an image consists of two parts, one is lower frequency or approximation of an image (scaling function) and another is

higher frequency or detailed part of an image (wavelet function). At every level of decomposition the four sub-images are obtained; the approximation (LL), the vertical detail (LH), the horizontal detail (HL) and the diagonal detail (HH). Then all the coefficients are discard, except the LL coefficients that are transformed into the second level.

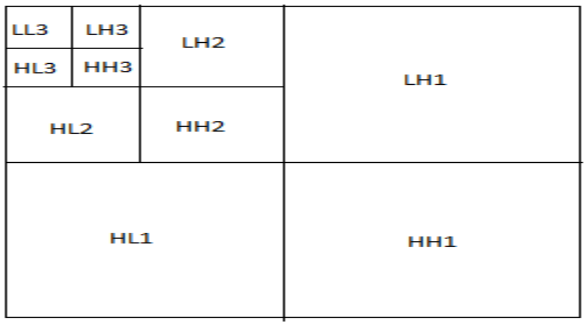
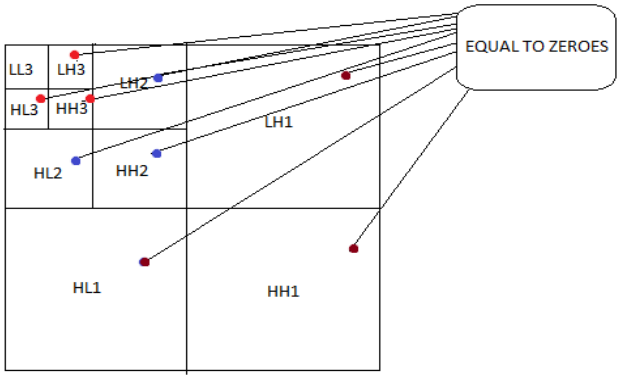


Figure 1: Wavelet Filter Decomposition

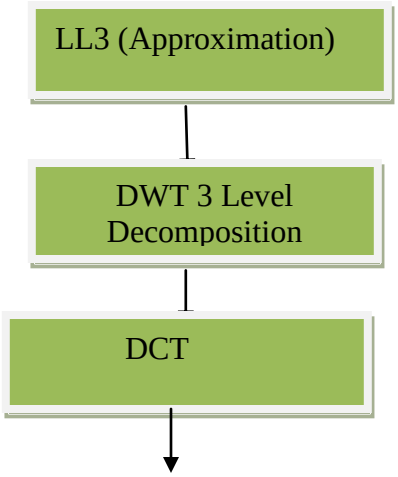
4. Hybrid (DWT+DCT) Transform

The Hybrid (DWT+DCT) transform satisfy both the advantages of DWT & DCT so that in this transform storage size reduced with higher compression ratio and The image is analysed by DWT upto three level, as a result we get approximation images of size 8 x 8 and make detail coefficients images is equal to zeroes. The 2- D DCT is applied on approximation image. Then quantized and send for coding.

Step 1:



Step 2:



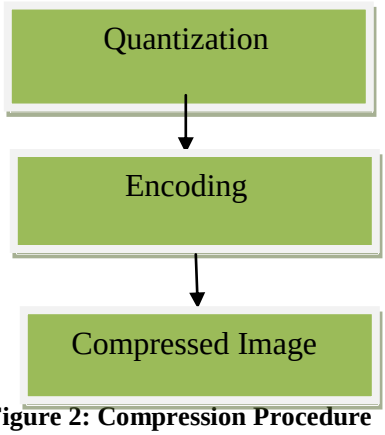


Figure 2: Compression Procedure

Step 3:

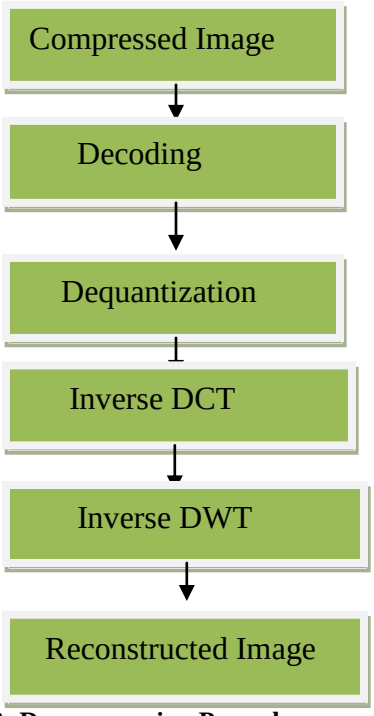


Figure 3: Decompression Procedure

5. Performance Parameters

Comparative analysis of these three transform following measures are used for achieve higher compression ratio and quality of image.

5.1 Mean Square Error (MSE)

Mean square error is a criterion for an estimator the choice is the one that minimizes the sum of squared errors due to bias and due to variance.

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

A = original image of size MxN
B = reconstructed image of size MxN

5.2 Peak Signal to Noise Ratio (PSNR)

It is ratio between the maximum possible power of a signal and the power of corrupting noise, because many signals have a very wide dynamic range. The PSNR is most commonly used to measure the quality of reconstructed image.

$$PSNR = 10 \log 255^2 / MSE$$

5.3 Compression Ratio (CR)

Compression ratio is defined as the ratio between the uncompressed image size and compressed image size.

$$\text{Compression Ratio (CR)} = \frac{\text{UNCOMPRESSED IMAGE SIZE}}{\text{COMPRESSED IMAGE SIZE}}$$

5.4 Bits Per Pixel (BPP)

Bits per pixel ratio (BPP) give the number of bits store one pixel of the image.

$$\text{Bits per Pixel} = \frac{\text{SIZE OF COMPRESSED FILE}}{\text{TOTAL NO. OF PIXEL IN THE IMAGE}}$$

6. Experimental Results

Figure 4: Original Couple Image of size 189KB

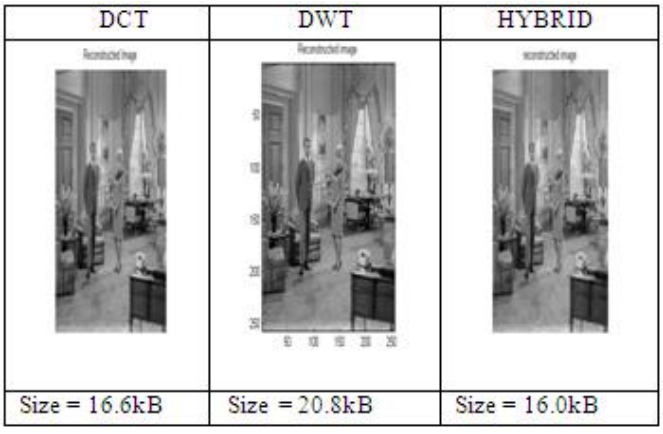


Figure 5: Reconstructed Couple Images

Image name	DWT	DCT	HYBRID
	COMPRESSION RATIO		
CAMERAMAN	22.3	28.4	34.8
COUPLE	20.1	25.3	26.2
VEHICLE	18.5	22.6	24
BABOON	16.9	20.8	22

Table 1: Results of Compression Ratio (CR)

Image name	DWT	DCT	HYBRID
	BITS PER PIXEL		
CAMERAMAN	0.3589	0.2814	0.2553
COUPLE	0.3972	0.3169	0.3042
VEHICLE	0.4324	0.3529	0.34
BABOON	0.4735	0.3855	0.3635

Table 2: Results of Bits per Pixel (BPP)

Image name	DWT	DCT	HYBRID
	PEAK SIGNAL TO NOISE RATIO		
CAMERAMAN	58.4	32	28.9
COUPLE	53.8	29.3	30
VEHICLE	50.9	31.9	24.6
BABOON	45.1	28	26.7

Table 3: Results of Peak Signal to Noise Ratio (PSNR)

7. Conclusions

In this paper, image compression and decompression by DCT, DWT and Hybrid by considering several images as inputs, it is observed that compression ratio is high and bits per pixel are reduced as compared to DCT and DWT. In future work we try to improve the quality of image compared to DCT and DWT using Huffman or arithmetic coding in Hybrid DWT and DCT.

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