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COMPARATIVE STUDY OF DCT, DWT & HYBRID (DCT-DWT) TRANSFORM USING N LEVEL OF DECOMPOSITION

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ABSTRACT: Image compression is the application of compression data .It is the technique used to reduce the redundancies in data representation in order to decrease the data storage requirements, transmission speed and communication costs. 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 comparative study of image compression is done by three transform methods which are Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT) & Hybrid (DCT+DWT) Transform using n level of decomposition by spatial density. The algorithm performs the discrete cosine transform (DCT) on the discrete wavelet transform (DWT) coefficient. Matlab programs were written for the above three method. Spatial filtering is a term used to describe the methods used to compute spatial density estimates for events observed at individual locations .The experimental result obtained from the study shows that hybrid DCTWT algorithm performs better than the DCT,DWT algorithm in term of peak signal to noise ratio(PSNR),and mean square error(MSE) with high compression ratio .
Keywords: Image compression, DCT, DWT, HYBRID (DCT+DWT), spatial density

I. INTRODUCTION

Compression is a process by which the description of computerized information is modified so that the capacity required to store or the bit-rate required to transmit it is reduced. 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. In this paper we made a comparative analysis of three transform coding techniques, viz. DCT, DWT and hybrid i.e. combination of both DCT and DWT based on different performance measure such as Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Compression Ratio (CR), computational complexity .The Joint Photographic Expert Group (JPEG) is the best choice for digitized photographs based on the Discrete Cosine Transform (DCT). It has been one of the most widely used compression method. 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. 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 order to benefit from the respective strengths of individual popular coding schemes, a new scheme, known as hybrid-algorithm, has been developed where two transforms techniques are implemented together. There have been few efforts devoted to such hybrid implementation. This paper is divided as follows: Section 1 explains Discrete Cosine Transform (DCT) algorithm; Section 2 describes the Discrete Wavelet Transform (DWT) algorithm; combination of both DCT and DWT algorithm explained in Section 3; section 4 describe the spatial density by spatial filtering; Section 5 included error metrics and in last Section gives the conclusions.

II. DISCRETE COSINE TRANSFORM

Discrete Cosine Transform (DCT) exploits cosine functions, it transform a signal from spatial representation into frequency domain. The DCT represents an image as a sum of sinusoids of varying magnitudes and frequencies. The process may be acquired as such given under:

1. The image first is broken into 8x8 blocks of pixels.
2. The DCT is applied to each blocks, it is working from left to right, top to bottom.
3. Each block is compressed using quantization table.
4. The array of compressed blocks that comprise the image is stored in a drastically reduced amount of space.
5. When the desired image is reconstructed through decompression known as a process that uses the Inverse Discrete Cosine Transform (IDCT)..The DCT for an N×N input sequence can be defined as

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

Where

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

M(x,y) is the original data of size x* y

The quantization is achieved by dividing each elements of the transformed original data matrix by corresponding element in the quantization matrix Q and rounding to the nearest integer value as

$$D_{quant}(i,j) = round\left(\frac{D_{DCT}(i,j)}{Q(i,j)}\right)$$

Further compression is achieved by applying appropriate scaling factor. The entire procedure for DCT is shown below:

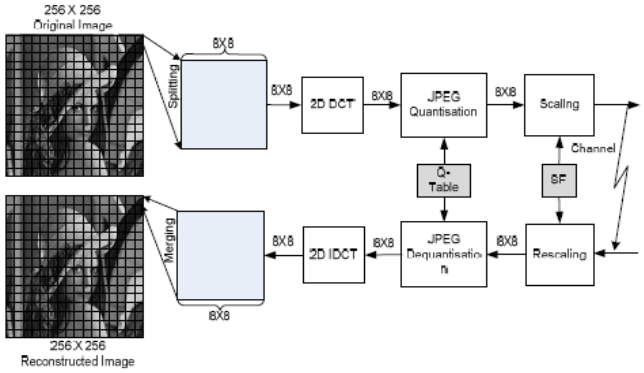

Figure: 1 Block diagram of the JPEG-based DCT scheme

III. DISCRETE WAVELET TRANSFORM

Wavelets are mathematical functions that cut up data into different frequency components. The fundamental idea behind wavelets is to analyze the signal at different scales or resolutions, which is called multi resolution. Multi resolution 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. Transform represents the data into a set of high pass (detail) and low pass (approximate) coefficients. The decomposition of wavelet filter is as shown:

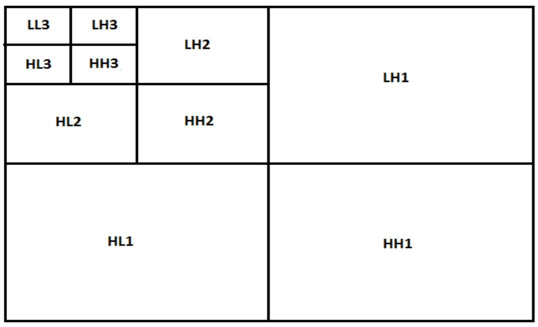

FIGURE 2: Wavelet Filter Decomposition

At every level, four sub-images are obtained; the approximation, the vertical detail, the horizontal detail and the diagonal detail. The approximation details can then be put through a filter bank, and this is repeated until the required level of decomposition has been reached. The image is first divided into blocks of 32×32. Each block is then passed through the two filters: the first level decomposition is performed to decompose the input data into an approximation and detail coefficients. After obtaining the transformed matrix the detail and approximate coefficients are separated as LL, HL, LH, and HH coefficients. All the coefficients are discarded, except the LL coefficients that are transformed into the second level. The coefficients are then passed through a constant scaling factor to achieve the desired compression ratio. An illustration is show n in Fig. 2. Here, x[n] is the input signal, d[n] is the high frequency component, and a[n] is the low frequency component. For data reconstruction, the coefficients are rescaled and padded with zeros, and passed through the wavelet filters.

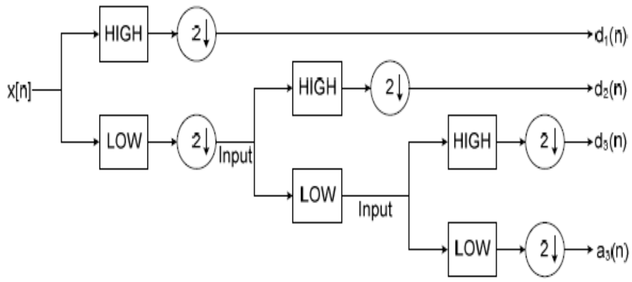

FIGURE 3: Block diagram of the 2-level DWT scheme

IV. PROPOSED HYBRID DWT- DCT

In section 2 and 3 we presented two different ways of achieving the goals of image compression, which have some advantages and disadvantages, in this section we are proposing a transform technique that will exploit advantages of DCT and DWT, to get compressed image. Hybrid DCT-DWT transformation gives more compression ratio compared to JPEG and JPEG2000, preserving most of the image information and create good quality of reconstructed image. Hybrid (DCT+DWT) Transform reduces blocking artifacts, false contouring and ringing effect. By giving consideration to the type of application, original image of size 256×256 or any resolution, provided divisible by 32, is first divided into blocks of N×N. Then each block is decomposed using 2-D DWT. Now low frequency coefficients (LL) are passed to the next stage where the high frequency coefficients (HL, LH, and HH) are discarded. Then the past LL components are further decomposed using another 2_D DWT. The 8-point DCT is applied to the DWT Coefficients. To achieve a higher compression, majority of high coefficients can be discarded. To achieve more compression a JPEG like quantization is performed. In this stage, many of the higher frequency components are rounded to zero. The quantized coefficients are further scaled using scaling factor (SF). Then the image is reconstructed by following the inverse procedure. During inverse DWT, zero values are padded in place of detailed coefficients.

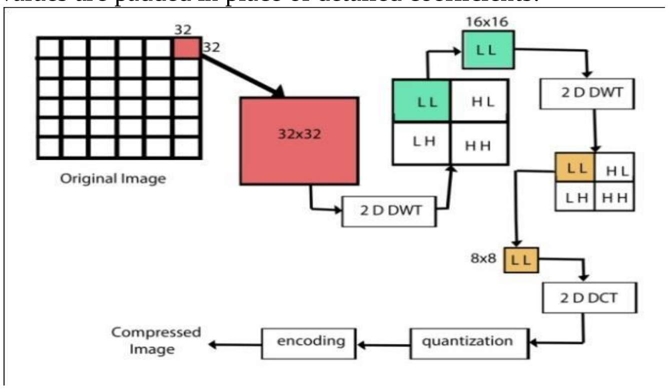

FIGURE 4: Compression technique using Hybrid transform

V. SPATIAL FILTERING

Spatial filtering is a term used to describe the methods used to compute spatial density estimates for events observed at individual locations. Spatial prediction does not out-perform pure DCT based technique (such as JPEG) in terms of bit-rate tradeoff. However, at very low bit rates it results in far fewer blocky artifacts and markedly better visual quality. It describes a set of tools for displaying functions estimated from these data points that are distributed in two-dimensional space. The algorithm employs a two-dimensional (2-D) filter in the areas away from edges, and for near edges, one-dimensional (1-D) filter aligned parallel to edge so as to reduce the blocking artifacts. So for removing blocking artifacts near edges we need spatial filtering.

VI. ERROR METRICS

COMPRESSION RATIO: It is a measure of the reduction of detail coefficient of data.

$$CR = \frac{Discarded \quad data}{Original \quad data}$$

MEAN SQUARE ERROR (MSE):

Mean square error is defined as the average of the square of the difference between the desired response and the actual system output.

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

Where I(x,y) is the original image, I'(x,y) is the approximated version and M,N are the dimensions of the images.

PEAK SIGNAL-TO-NOISE RATIO (PSNR):

It is the ratio between the maximum possible power of a signal and the power of corrupting noise. The PSNR is most commonly used as a measure of quality of reconstruction in image compression etc.

$$PSNR = 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) = 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right)$$

It is most easily defined via the mean squared error (MSE) which for two m×n monochrome images I and K where one of the images is considered noisy.

VII. CONCLUSION

In this paper comparative study of various Image compression techniques is done based on three parameters compression ratio(CR), mean square error (MSE), peak signal to noise ratio (PSNR). We find out that DWT technique is more efficient by quality wise than DCT and by performance wise DCT is much better than DWT. But, as Hybrid DCT-DWT is combination of both, it will be much better than the other two. The new scheme performs better in a noisy environment and reduces the false contouring effects and blocking artifacts significantly.

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