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RESEARCH ARTICLE

Comparative Analysis of Image Compression Using DCT and DWT Transforms

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Abstract: Compression refers to reducing the quantity of data used to represent a file, image or video content without excessively reducing the quality of the original data. Image compression is the application of data compression on digital images. 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. Depending on the reconstructed image, to be exactly same as the original or some unidentified loss may be incurred, two techniques for compression exist. Two techniques are: lossy techniques and lossless techniques. In this paper, we are analyzing comparative performance of DCT & DWT transforms based on various parameters.

Keywords: compression, DCT, DWT, PSNR

I. INTRODUCTION

Image compression is the application of data compression on digital images. 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. Image compression may be lossy or lossless. Lossless compression is preferred for archival purposes and often for medical imaging, technical drawings, clip art, or comics. Lossy compression methods, especially when used at low bit rates, introduce compression artifacts. Lossy methods are especially suitable for natural images such as photographs in applications where minor (sometimes imperceptible) loss of fidelity is acceptable to achieve a substantial reduction in bit rate. The lossy compression that produces imperceptible differences may be called visually lossless. Image compression is an important issue in digital image processing and finds extensive applications in many fields. This is the basic operation performed frequently by any digital photography technique to capture an image. For longer use of the portable photography device it should consume less power so that battery life will be more. To improve the Conventional techniques of image compressions using the DCT have already been reported and sufficient literatures are available on this. The JPEG is a lossy compression scheme, which employs the DCT as a tool and used mainly in digital cameras for compression of images. In the recent past the demand for low power image compression is growing. As a result various research workers are actively engaged to evolve efficient methods of image compression using latest digital signal processing techniques. The objective is to achieve a reasonable compression ratio as well as better quality of reproduction of image with low power consumption.

II. RELATED WORK

Prabhakar.Telagarapu et al. [3] have described the analysis of compression using DCT and Wavelet transform by selecting proper threshold method, better result for PSNR have been obtained. Extensive experimentation has been carried out to arrive at the conclusion. By considering several images as inputs, it is observed that MSE is low and PSNR is high in DWT than DCT based compression. From the results it is concluded that overall performance of DWT is better than DCT on the basis of compression rates. Nageswara Rao Thota et al. [4] have described the lossy compression techniques have been used, where data loss cannot affect the image clarity in this area. JPEG is a still frame compression standard, which is based on, the Discrete Cosine Transform and it is also adequate for most compression applications. The discrete cosine transform (DCT) is a mathematical function that transforms digital image data from the spatial domain to the frequency domain. K.Saraswathy et al. [5] have described an orthogonal approximation for the 8 point Discrete Cosine Transform (DCT). The proposed transformation matrix contains only ones and zeros. Bit shift operations and multiplication operations are absent. The approximate transform of DCT is obtained to meet the low complexity requirements. The simulation results obtained from the work will shows clearly the efficiency of the proposed transform in image compression. Finally, the new approximation offers the users another options for mathematical analysis and circuit implementations. Li Wern Chew,Ang, Li-Minn and KahPhooiSeng, in “Survey of image compression algorithms in wireless sensor networks”[7], presented a review on eight popular image compression algorithms. After conducting a comprehensive evaluation, it was found that Set-Partitioning in Hierarchical Trees (SPIHT) wavelet-based image compression is the most suitable hardware implemented image compression algorithm in wireless sensor networks due to its high compression efficiency and its simplicity in coding procedures. O. Rioul and P.Duhamel, reviewed several algorithms for computing various types of wavelet transforms: the Mallat algorithm (1989), the 'a trous' algorithm, and their generalizations by Shensa. The goal of this work was to develop guidelines for implementing discrete and continuous wavelet transforms efficiently, and to compare the various algorithms obtained and give an idea of possible gains by providing operation counts.

III. 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. DCT has the property that, for a typical image most of the visually significant information about an image is concentrated in just few coefficients of DCT. After the computation of DCT coefficients, they are normalized according to a quantization table with different scales provided by the JPEG standard computed by psycho visual evidence. Selection of quantization table affects the entropy and compression ratio. The value of quantization is inversely proportional to quality of reconstructed image, better mean square error and better compression ratio. In a lossy compression technique, during a step called Quantization, the less important frequencies are discarded, Then the most important frequencies that remain are used to retrieve the image in decomposition process. [4]. After quantization, quantized coefficients are rearranged in a zigzag order for further compressed by an efficient lossy coding algorithm. 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 [5]:

$$D(i,j) = \frac{1}{\sqrt{2N}} C(i)C(j) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} P(x,y) \times \cos\left(\frac{(2x+1)i\pi}{2N}\right) \cos\left(\frac{(2y+1)j\pi}{2N}\right)$$

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

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

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

$$P(x,y) = \frac{1}{\sqrt{2N}} \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} C(i)C(j)D(i,j) \times \cos\left(\frac{(2x+1)i\pi}{2N}\right) \cos\left(\frac{(2y+1)j\pi}{2N}\right)$$

The pixels of black and white image are ranged from 0 to255, where 0 corresponds to a pure black and 255 corresponds to a pure white. As DCT is designed to work on pixel values ranging from -128 to 127, the original block is leveled off by 128 from every entry. Step by step procedure of getting compressed image using DCT can be illustrated through flow charts as shown in fig.1.

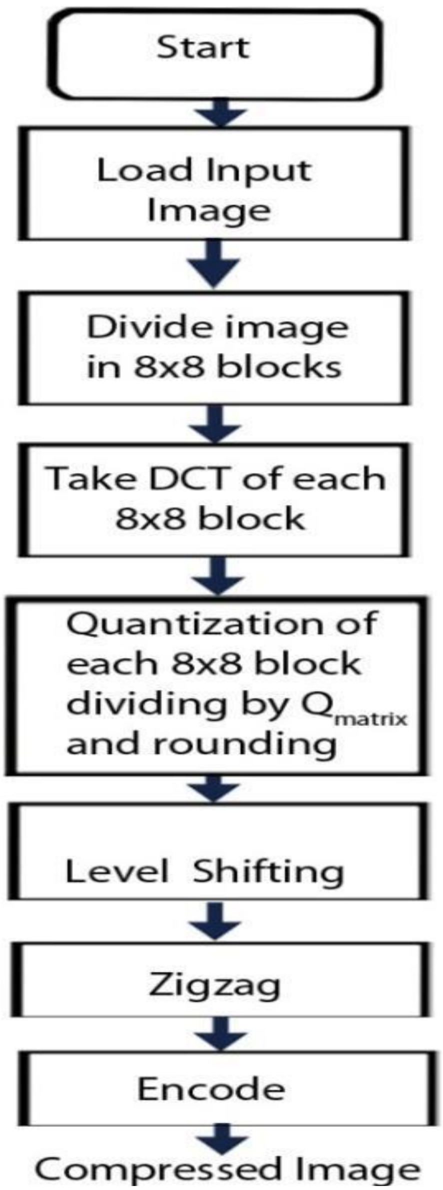

Fig1. DCT Compression flow chart

IV. DISCRETE WAVELET TRANSFORM (DWT)

Wavelets are useful for compressing signals. They can be used to process and improve signals, in fields such as medical imaging where image degradation is not tolerated. Wavelets can be used to remove noise in an image. Wavelets are mathematical functions that can be used to transform one function representation into another. Wavelet transform performs multi resolution image analysis. 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. The 2D wavelet analysis uses the same 'mother wavelets' but requires an extra step at every level of decomposition.

In 2D, the images are considered to be matrices with N rows and M columns. Any decomposition of an image into wavelets involves a pair of waveforms-

- One to represent the high frequency corresponding to the detailed part of the image (wavelet function)
- One for low frequency or smooth parts of an image (scaling function).

At every level of decomposition the horizontal data is filtered, then the approximation and details produced from this are filtered on columns. At every level, four sub-images are obtained; the approximation, the vertical detail, the horizontal detail and the diagonal detail. Wavelet function for 2-D DWT can be obtained by multiplying wavelet functions ($\Psi(x,y)$) and scaling function ($\varphi(x,y)$). After first level decomposition we get four details of image those are,

Approximate details – $\Psi(x,y) = \varphi(x)\,\varphi(y)$

Horizontal details – $\Psi(x,y) = \varphi(x)\Psi(y)$

Vertical details – $\Psi(x,y) = \Psi(x)\varphi(y)$

Diagonal details – $\Psi(x,y) = \Psi(x)\,\Psi(y)$

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 filtering step is followed by a sub-sampling operation that decreases the resolution from one transformation level to the other. After applying the 2-D filler bank at a given level n, the detail coefficients are output, while the whole filter bank is applied again upon the approximation image until the desired maximum resolution is achieved. Fig.1 shows wavelet filter decomposition. The sub-bands are labeled by using the following notations [6],

- LLn represents the approximation image nth level of decomposition, resulting from low-pass filtering in the vertical and horizontal both directions.
- LHn represents the horizontal details at nth level of decomposition and obtained from horizontal low-pass filtering and vertical high-pass filtering.
- HLn represents the extracted vertical details/edges, at nth level of decomposition and obtained from vertical low-pass filtering and horizontal high-pass filtering.
- HHn represents the diagonal details at nth level of decomposition and obtained from high-pass filtering in both directions.

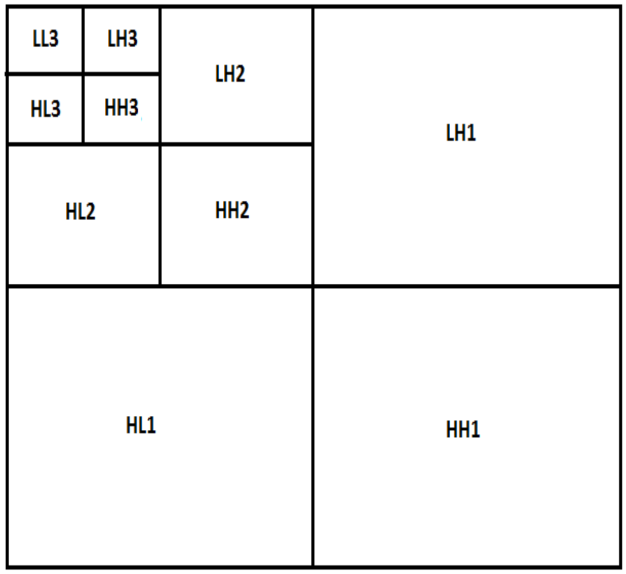

Fig.2 Wavelet Filter Decomposition

V. COMPARATIVE ANALYSIS AND RESULTS

For comparative analysis codes for DCT & DWT were written in MATLAB and results were obtained for various parameters like mean square error (MSE), peak signal to noise ratio (PSNR) etc. obtained results shows that 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.

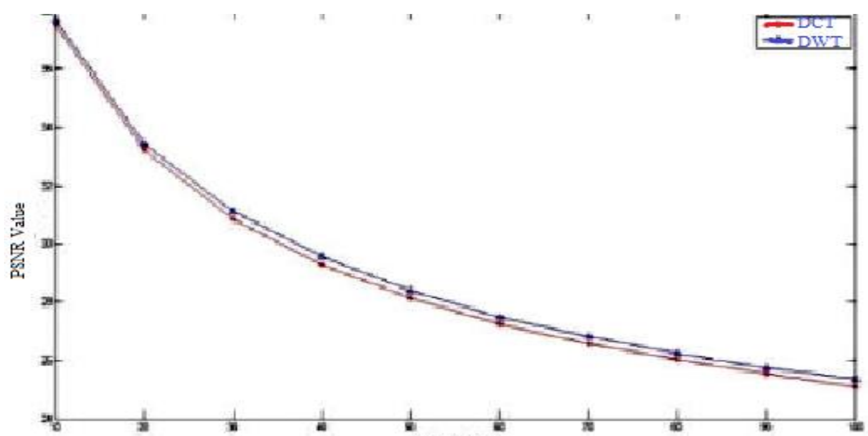

Fig3. PSNR value of DWT & DCT

VI. CONCLUSION

In this paper comparative analysis of image compression is done by two transform methods, which are Discrete Cosine Transform (DCT) & Discrete Wavelet Transform (DWT). DWT gives more compression ratio and high quality of reconstructed image, it adds speckle noise to the image for improvement in the reconstructed image. Hence DWT technique is useful in medical applications. DCT gives less compression ratio but it is computationally efficient compared to other techniques.

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