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An Improved Image Compression Technique Using DCT and DWT

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ABSTRACT

Now a day's Create, edit, and generate images in a very regular system for transmission is main priority. Original image data generated by the camera sensor is a very large store, and therefore is not efficient. It has become particularly troublesome to move or bandwidth-limited systems wherein the object is to be conservative bandwidth cost, such as the World Wide Web. This scenario requires the use of efficient image compression techniques, such as the JPEG algorithm technology, the quality of the compressed image height to which the perceived image with almost no loss. Today JPEG algorithms have become the real standard for image compression. This paper presents DWT and DCT implementation because these are the lossy techniques

I. INTRODUCTION

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. 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. [9]

For this purpose many compression techniques i.e. scalar/vector quantization, differential encoding, predictive image coding, transform coding have been introduced. Among all these, transform coding is most efficient especially at low bit rate. Depending on the compression techniques the image can be reconstructed with and without perceptual loss. In lossless compression, the reconstructed image after compression is numerically identical to the original image. In lossy compression scheme, the reconstructed image contains degradation relative to the original. Lossy technique 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. The approaches for lossy compression include lossy predictive coding and transform coding. Transform coding, which applies a Fourier-related transform such as DCT and Wavelet Transform such as DWT are the most commonly used approach. [8]

JPEG is the best choice for digitized photographs. The Joint Photographic Expert Group (JPEG) system, based on the Discrete Cosine Transform (DCT), has been the most widely used compression method. Discrete Cosine Transform (DCT) is an example of transform coding. The DCT coefficients are all real numbers unlike the Fourier Transform. The Inverse Discrete Cosine Transform (IDCT) can be used to retrieve the image from its transform representation. DCT is simple when JPEG used, for higher compression ratio the noticeable blocking artifacts across the block boundaries cannot be neglected. The DCT is fast. It can be quickly calculated and is best for images with smooth edges. Discrete wavelet transform (DWT) has gained widespread acceptance in signal processing and image compression. In this paper we made a comparative analysis of two transform coding techniques DCT and DWT based on different performance measure such as Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) and Compression Ratio (CR).

II. RELATED WORK

Prabhakar. Telagarapu et al. (2011) [1] in paper "Image Compression Using DCT and Wavelet Transformations" 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.

Vellaiappan Elamaran et al. (2012) [2] in paper „Comparison of DCT and Wavelets in Image coding‟ have described the basic idea of compression is to try to reduce the average number of bits per pixel to adequately represent the image. Fourier based transforms (e.g. DCT and DFT) are efficient in exploiting the low frequency nature of an image. The high frequency coefficients are coarsely quantized, and hence the reconstructed quality of the image at the edges will have poor quality. On the other hand, wavelets are efficient in representing non stationary signals because of the adaptive time-frequency window. So the Discrete Wavelet Transform (DWT) is applied to an image and the PSNR of both Discrete Cosine Transform (DCT) and DWT is compared. An analysis and comparison of image compression using DCT and DWT is demonstrated.

Nageswara Rao Thota et al. (2008) [3] in this paper „Image Compression Using Discrete Cosine Transform‟ 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. The system is designed by using MATLAB software. This project has been tested for all possible situations on MATLAB environment. One of the main problems and the criticism of the DCT is the blocking effect. In DCT, images are broken into blocks of 8x8 or 16x16 or bigger. The problem with these blocks is that when the image is reduced to higher compression ratios, these blocks become visible.

K.Saraswathy et al. (2013) [4] in this paper „A DCT Approximation with Low Complexity for Image Compression‟ 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. The new approximate transform matrix has rows constructed from a different mathematical structure when compared to DCT. These rows can be considered in the design of hybrid algorithm which mat take advantage of the best matrix rows from the existing algorithm aiming at novel improved approximate transform.

Maneesha Gupta et al. (2012) [5] in this paper „Analysis Of Image Compression Algorithm Using DCT‟ have described that here we develop some simple functions to compute the DCT and to compress images. An image compression algorithm was comprehended using Matlab code, and modified to perform better when implemented in hardware description language. Image Compression is studied using 2-D discrete Cosine Transform. The original image is transformed in 8-by-8 blocks and then inverse transformed in 8-by-8 blocks to create the reconstructed image. The inverse DCT would be performed using the subset of DCT coefficients. The error image (the difference between the original and reconstructed image) would be displayed.

Sonja Grgic, et al. (2009) [6] in this paper "Image Compression Using Wavelets" examines a set of wavelet functions (wavelets) for implementation in image compression system and to highlight the benefit of this transform relating to today‟s methods. The effects of different wavelet functions, image contents and compression ratios are assessed. A comparison with a discrete-cosine-transform-based compression system is given. The results provide a good reference for application developers to choose a good wavelet compression system for their application. The final choice of optimal wavelet in image compression application depends on image quality and computational complexity.

Amina Khatun et al. (2012) [7] in this paper "Image Compression Using Discrete Wavelet Transform" have described the new image compression scheme with pruning proposal based on discrete wavelet transformation (DWT). The effectiveness of the algorithm has been justified over some real images, and the performance of the algorithm has been compared with other common compression standards. Experimental results demonstrate that the proposed technique provides sufficient high compression ratios compared to other compression techniques. A new image compression scheme based on discrete wavelet transform is proposed which provides sufficient high compression ratios with no appreciable degradation of image quality. The effectiveness and robustness of this approach has been justified using a set of real images. To demonstrate the performance of the proposed method, a comparison between the proposed technique and other common compression techniques has been revealed. From the experimental results it is evident that, the proposed compression technique gives better performance compared to other traditional techniques.

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.

The image is divided into 8x8 pixel blocks and 2D-DCT is applied to each. Coarse quantization is applied to high spatial frequency components. Thus compressing the resulting data losslessly and stored. Spatial frequencies are scanned in zig- zag pattern so that high frequencies will become mostly zero. Huffman encoding may be used to losslessly record values in table. [8]

IV. DISCRETE WAVELET TRANSFORM

Another method of decomposing signals that has gained a great deal of popularity in recent years is the use of wavelets. Decomposing a signal in terms of its frequency content using sinusoids results in a very fine resolution in the frequency domain, down to the individual frequencies. However, a sinusoid theoretically lasts forever; therefore, individual frequency components give no temporal resolution. In other words, the time resolution of the Fourier series representation is not very good. In a wavelet representation, we represent our signal in terms of functions that are localized both in time and frequency. Recently, wavelets have become very popular in image processing, specifically in coding applications for several reasons.

In the DCT compression algorithm

The input image is divided into 8-by-8 or 16-by-16 blocks

- The two-dimensional DCT is computed for each block
- The DCT coefficients are then quantized, coded, and transmitted.
- The receiver (or file reader) decodes the quantized DCT coefficients, computes the inverse two-dimensional DCT
- (IDCT) of each block. Puts the blocks back together into a single image

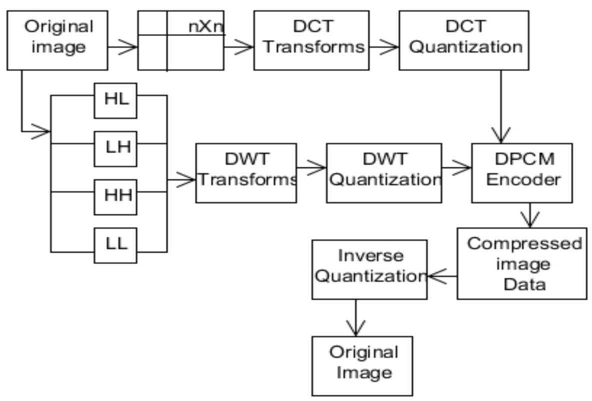

Figure.1.Architecture of DCT and DWT Comparison

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. [8]

V. ERROR METRICS

Two of the error metrics used to compare the various image compression techniques are the Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR) to achieve desirable compression ratios. The MSE is the cumulative squared error between the compressed and the original image, whereas PSNR is a measure of the peak error.

Logically, a higher value of PSNR is good because it means that the ratio of Signal to Noise is higher. Here, the 'signal' is the original image, and the 'noise' is the error in reconstruction. [10]

VI. DATA COMPRESSION RATIO

Data compression ratio, also known as compression power, is used to quantify the reduction in data-representation size produced by data compression. The data compression ratio is analogous to the physical compression ratio it is used to measure physical compression of substances, and is defined in the same way, as the ratio between the uncompressed size and the compressed size.

VII. 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. The average of the square of the difference between the desired response and the actual system output.

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

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

VIII. 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.

$$PSNR = 20 * \log_{10}\left(\frac{255}{\sqrt{MSE}}\right) \quad (2)$$

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. [10]

IX. SIMULATION RESULTS

PARAMETER	DCT	DWT
PSNR	112.8307	117.3514
MSE	3.3885e-07	1.1966e-007
TIME	22.572097 second	0.265885 seconds

Table 1:comparision between DCT and DWT

Fig 3. (a)Original image

(b) Compressed image of DCT

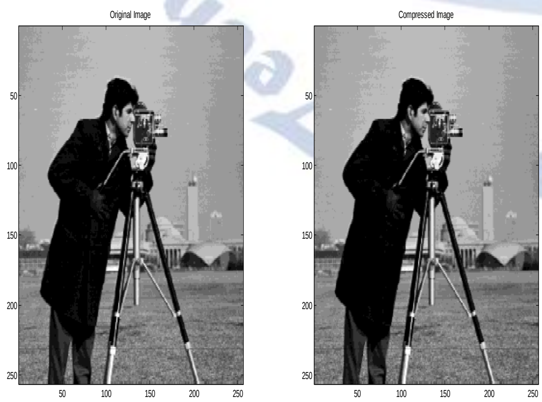

Fig 4: DWT of image compression

X. CONCLUSION

In this paper comparative analysis of various Image compression techniques for different images is done based parameters mean square error (MSE), peak signal to noise ratio (PSNR). DWT gives better results 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. DCT based standard JPEG uses blocks of image. In wavelet, there is no need to block the image.

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