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Digital Image Compression Using Hybrid Technique

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Abstract: ***Image compression is a widely addressed research area. Image compression refers to reducing the graphic file size without degrading the quality. The purpose of image compression is to not only reduce the graphic file size but also to decrease storage space requirement. Consequently cost of data transmission and time required for transmission is also reduced. There are various techniques to compress the data which efficiently transmit and store the data. DCT is a fast transform and provides excellent compaction for highly co-related data. DWT reduces the image size without degrading much of the resolution. DFT is used to calculate the frequency response of a signal. One example of DFT algorithm is FFT. FFT is an algorithm used for performing convolution of signals that is hundreds of times faster than traditional methods. In this paper, we combine these three image compression techniques to make two hybrid techniques i.e Hybrid DWT-DCT and Hybrid DWT-DFT. After comparing the individual techniques (DCT, DFT, DWT) that are used in combination and two hybrid techniques (hybrid DWT-DCT and hybrid DWT-DFT) with each other, it is observed that for a high level of compression, we need to hybrid the compression techniques and among two hybrid techniques, Hybrid DWT-DCT provides the best result.***

Keywords: DCT, DWT, DFT, CR, PSNR, MSE

I. INTODUCTION

An Image is a most usual and convenient way of sharing or transmitting information or data. In brief, images convey information about size, position and inter-relationship between the objects. They depict spatial information that we can recognize as objects. Image compression means to reduce the quantity of data used to represent a file, image or video content without reducing the quality of original data. The main purpose of image compression is to reduce the redundancy and irrelevancy present in the image, for it's better storage and transmission [1].

A common characteristic of most of the images is that the neighboring pixels are highly correlated and therefore contain redundant information. The basic objective of image compression is to find an image representation in which pixels are less correlated. In lossless compression, a text file or program can be compressed without the introduction of errors, but only up to certain level. Beyond this point, errors are introduced. When there is some tolerance for loss, the compression factor can be greater than it can be when there is no loss tolerance. For this reason, graphic images can be compressed more than text files or programs [2].

There are two types of image compression techniques: 1. Lossless compression technique 2. Lossy compression technique. In lossless compression technique, the bit rate of compressed output is reduced without degrading the image. Lossy compression technique is used where some of the details of an image can be sacrificed for the sake of a better compression [10].

II. VARIOUS TRANSFORMATION ALGORITHMS

A. Discrete Cosine Transform

DCT is a fast transform and it transforms a signal from spatial representation into frequency domain.

DCT represents an image as a sum of sinusoids of varying magnitudes and frequencies. DCT provides the benefit that most of the information that is visually significant about an image is represented in fewer coefficients of DCT [12].

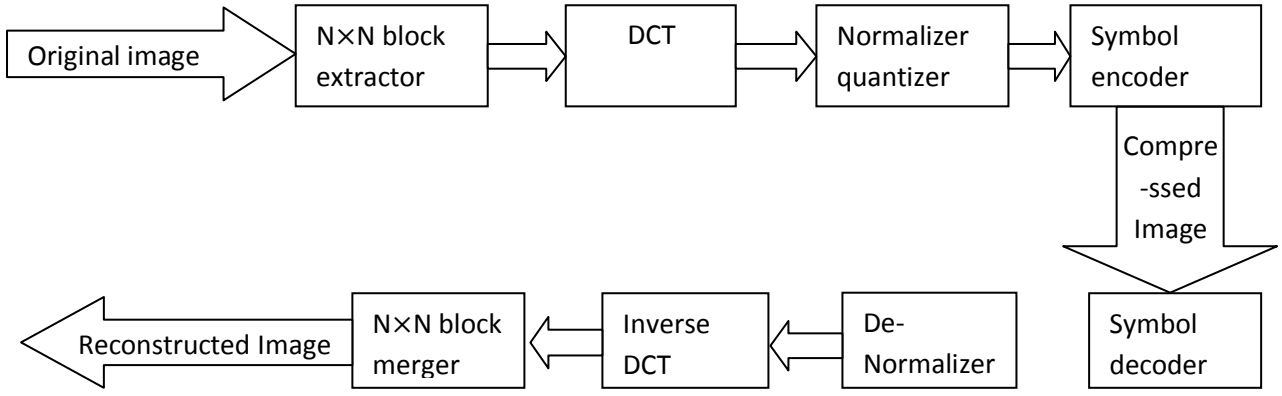

Fig.1 Image Compression and Decompression Using DCT

Proposed DCT algorithm [5]

Firstly, the image is divided into N×N blocks of pixels, then the DCT is applied to each block by working from left to right and top to bottom. Then Each block is compressed using quantization process. The array of compressed blocks that constitutes the image is stored in a reduced amount of space. Finally, the image is reconstructed through decompression that utilizes IDCT (Inverse Discrete Cosine Transform).

B. Discrete Wavelet Transform

DWT (Discrete Wavelet Transform) is used to reduce the size of images without degrading much of the resolution. It has become the most popular method for decomposing signals that make use of wavelets. In wavelet transformation, the signal is represented in terms of both time and frequency [1].

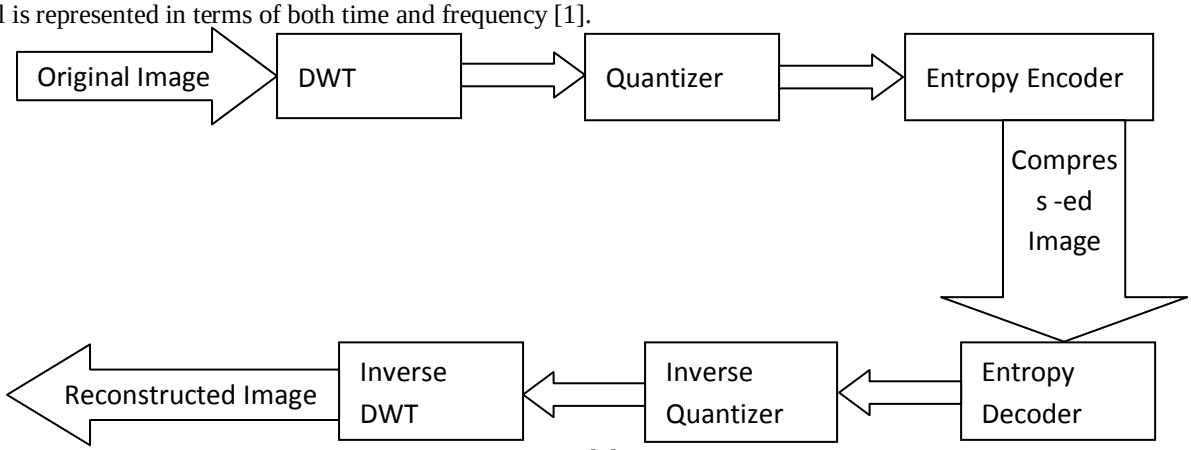

Fig.2 Image compression and decompression Using DWT

Proposed DWT algorithm [6]

Firstly, the image is divided into N×N blocks, and then each block is passed through two filters. In the first level, the decomposition is performed to decompose the input data into an approximation and detailed coefficients. After obtaining the transformed matrix, the approximate and detailed 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. For reconstruction of data, the coefficients are rescaled and padded with zeros and passed through the wavelet filters.

C. Discrete Fourier Transform

The Fourier transform is a fundamental method of image compression which converts an image from spatial domain to frequency domain.. In DCT, the input samples are complex numbers and the output coefficients are complex as well. The DFT is used to solve partial differential equations efficiently. It is also used to perform convolution or multiplication of large integers [3].

The DFT is calculated as:

$A_{yx}(y) = \int_{-\infty}^{\infty} a(x)e^{-2\pi yx}\,dx$

The Inverse DFT is calculated as:

$a(x) = \int_{-\infty}^{\infty} A_{yx}(y)\,e^{-2\pi yx}\,dy$

Proposed DFT algorithm [3]

Firstly, the image is divided into N×N blocks then fft2 function is applied for transforming the whole image blocks with Fourier transform. After that quantization is applied on transformed image. Quantization is the most important step in image compression. The 2-D fft2 is then computed for each block and the FFT coefficients are quantized and transmitted. After that de-quantized FFT coefficients are computed. The 2-D (inverse) IFFT2 of each block is computed and the blocks are put together into reconstructed images.

III. PROPOSED HYBRID ALGORITHMS

A. Hybrid DWT-DCT algorithm

1. Firstly, the image is divided into blocks of N×N and then each block is decomposed using 2-D DWT.
2. Low frequency coefficients (LL) are passed to the next stage where the high frequency coefficients (HL, LH and HH) are discarded. The passed LL components are further decomposed using another 2-D DWT.
3. Now the 8-point DCT is applied to these DWT coefficients. By discarding the majority of high coefficients, we can achieve a high compression. To achieve further compression, a JPEG-like quantization is performed. In this stage, many of the higher frequency components are rounded to zero.
4. The quantized coefficients are further scaled using scalar quantity known as scaling factor (SF). Each sub-band is to be quantized and the obtained zeros are to be eliminated. On applying 1-D DCT to each sub-band, it is converted to array by using quantization. This process is called T-MATRIX coding. This code is converted to binary data by Arithmetic coding.
5. Finally, the image is reconstructed following the inverse procedure.

B. Hybrid DWT-DFT algorithm

1. The wavelet transform separates the low frequency components (LL) form high frequency components (LH, HL, HH).
2. The low frequency components are passed to the next stage and decomposed further using 2-D DWT.
3. The FFT divides the original vector into two halves, computing the FFT of both halves and then putting the results together.
4. The FFT of an image of size M×N is computed in MATLAB using fft2 function. It computes its Fourier transform and display the spectrum.
5. This function returns a Fourier transform that is also of size M×N.

IV. ERROR METRICS

The error metrics that are used to compare the performance of different image compression techniques are:

A. Compression Ratio

Compression ratio is defined as the ratio of number of bits required to represent original image to the number of bits required to represent compressed image. Lossy compression techniques have higher compression ratio than lossless compression techniques [4]. It is expressed as:

$$CR = \frac{\text{DISCARDED DATA}}{\text{ORIGINAL DATA}}$$

B. Mean Square Error

Mean Square Error (MSE) [4] is the measure of error between the original image and the compressed image. For a high quality output and a fewer distortion, the MSE must be low. It is the cumulative squared error between the compressed image and the original image.

Mean Square Error is calculated as follows:

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

C. *Peak Signal to Noise Ratio*

It is a measure of peak error and expressed in logarithmic decibel scale. For a better compression, the peak signal to noise ratio (PSNR) must be high. [4]. The peak signal to noise ratio may be calculated as:

$$PSNR = 20\ LOG_{10}[max_i^2/\sqrt{MSE}]$$

V. RELATED WORK

In recent times, many studies have been carried out on image compression using different techniques. In [7] Gaurav Vijayvargia, Dr. Sanjay Silakari and Dr. Rajeev Pandey of UIT- RGPV Bhopal proposed a paper in which analysis on different types of image compression techniques has been carried out. On the premise of evaluation the numerous image compression Techniques, this paper reveals a review of existing research papers. It is drastically different to compress a binary raw data as compared to compress an image. To solve these distinctive sorts of procedure for image compression, there are primarily two kinds of image compression techniques: lossy and lossless techniques. After taking a look on all strategies, it is observed that lossless image compression techniques are best over lossy compression techniques. Lossy gives a higher compression ratio than lossless.

In [8] Navpreet Saroya and Prabhpreet Kaur of GNDU, Amritsar proposed a paper in which comparative analysis of numerous image compression techniques for distinct images is performed. The analysis is done based on two basic metrics namely PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error). DWT provides better results without losing excessive information of the image. The only drawback of DWT is that it requires more power for processing. On the other hand, DCT overcomes this drawback as it requires less processing power but it provides lesser compression ratio. Moreover DCT based standard JPEG utilizes blocks of images but there is no need to block the image in DWT.

In [9] Pabbisetti Sathayanarayana and Hamid R. Saeedipour of Universiti Sains Malaysia, proposed a paper in which three techniques for data compression as well as decompression process are presented which are: 1. Discrete Hartley type transformation (DHT), 2. Fast Fourier transform (FFT) 3. Discrete cosine transforms (DCT). The authors have also given the comparison of original image with respect to mean square error. The MSE (Mean Square Error) is nearly same for all the methods for different compression factors. This work reveals that CCT technique can be used for image compression rather than FFT method. The various advantages of CCT method over FFT method are: CCT method is a real transform; as a result the number of multiplications and additions is less as compared to FFT method. Secondly storage decreases to half of that of FFT. Moreover the requirement for transmission bandwidth also decreases with CCT instead of FFT. Therefore image compression as well as decompression techniques can be more effectively implemented by using CCT method. DCT technique also provides almost similar performance as that of CCT.

In [10] Prabhakar. Telagarapu, V. jagan Naveen, A. Lakshmi Prasanthi and G. Vijay santhi of GMR institute of technology, Andhra Pradesh proposed a paper in which analysis of compression using DWT i.e. Discrete Wavelet Transform and DCT i.e. Discrete Cosine Transform by choosing proper threshold technique has been done. As a result better PSNR is obtained. Moreover, it is found that MSE is low and PSNR is high in DWT and DCT techniques. After successful experimentations, it is found that overall performance of DWT is better as compared to DCT if we compare them on the basis of compression rates. To represent the point singularities, the most suitable way is to use Wavelets but

it cannot represent line singularities. By using a new transform that is Ridge Let transform, this paper can be extended for line singularities.

In [11] Rajesh K. Yadav, S.P. Gangwar and Harsh V. Singh of N.D University of Agriculture & technology, Kumarganj, Faizabad proposed a paper in which complete study with overall performance evaluation of an image compression technique that is based on wavelet transform is presented. The process of DWT consists of decomposition i.e. transform of image, thresholding of coefficients and entropy encoding. The main purpose of this paper is to describe the transform of an image with the help of DWT and thresholding technique. In this paper, the standard image Lena of size 256X256 of eight bit depth is taken and DWT (haar) is applied. Then two result sets are obtained by making use of two different types of thresholding techniques after which results are compared.

In [1] Bhonde Nilesh, Shinde Sachin, Nagmode Pradeep and D.B. Rane proposed a paper in which they presented a new image compression technique which is based on DWT i.e. Discrete Wavelet Transform. This technique provides enough high compression ratios but no effective degradation in quality of image. The images are captured by a digital camera (OLYMPUS LI-40C). To illustrate the overall performance of the proposed technique, a contrast between the proposed method and other techniques has been done. After successful experimentations, it is observed that the proposed image compression technique provides better performance as compared to the other conventional techniques. This work can be extended by implementing an image compression technique using neural network.

VI. CONCLUSION

In this paper, we are studying various image compression techniques like DCT, DFT and DWT. Among these techniques, wavelet provides higher compression ratio with less degradation. For higher level of compression, we need to hybrid these compression techniques. So we have proposed two hybrid techniques i.e. Hybrid DWT-DCT and Hybrid DWT-DFT with the help of these three techniques. After successful experimentation, we have concluded that the combination of DCT and DWT provides better results with higher compression ratio.

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