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IMAGE COMPRESSION USING COMBINATION OF DIFFERENT TRANSFORM TECHNIQUES

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ABSTRACT

Image compression is the art/science of efficiently coding digital images to reduce the number of bits required in the representing an image. The purpose of doing so is to reduce the storage and transmission costs while maintaining good quality In this paper work, combination of different transform schemes , the DHT, the DWT and the DCT algorithms under high compression ratio constraint for image compression has been studied. The presented combination of (DHT+DCT+DWT) transform technique has shown significantly better results .The study also showed, that the high value of PSNR is obtained for the same compression ratio. In addition, it was observed that the proposed algorithm has better performance as compared to the other stand alone algorithms. It was observed that the proposed combination of algorithm performs better than the existing algorithms. The proposed scheme is intended to be used as the image compressor engine in imaging and applications where high compression is required.

Keywords- DCT, DHT, DWT, Image Compression, Peak Signal to Noise Ratio

I. INTRODUCTION

The usage of digital image in various applications is growing rapidly. Video and television transmission is becoming digital and more and more digital image sequences are used in multimedia applications. Image compression is used to reduce the amount of data required for representing sampled digital images and therefore reduce the cost for storage and transmission. A digital image is composed of pixels, which can be thought of as small dots on the screen and it becomes more complex when the pixels are colored [1]. To store these images, and make them available over network compression techniques are needed. Digital image and video compression is now essential. The problem with images and videos is that they require a large amount of bandwidth the send and receive. Therefore there is a need to decrease the size of the image or video sent or received. Image compression has been becoming increasingly important with the development of aviation, communications, internet and space techniques; especially lossless compression becomes indispensable when there is no loss of information is tolerable such as medical image, remote sensing, image archiving, and satellite communications and so on.. To make this fact clear let's see an example. An image, 1024 pixel $\times$ 1024 pixel $\times$

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24 bit, without compression, would require 3 MB of storage and 7 minutes for transmission, utilizing a high speed, 64 Kbit/s, ISDN line. If the image is compressed at a 10:1 compression ratio, the storage requirement is reduced to 300 KB and the transmission time drops to under 6 seconds. There a Image compression is the art/science of efficiently coding digital images to reduce the number of bits required in the representing an image. The purpose of doing so is to reduce the storage and transmission costs while maintaining good quality [2].

To compress something means that you have a piece of data and you decrease its size. There are different techniques who to do that and they all have their own advantages and disadvantages. One trick is to reduce redundant information, meaning saving sometimes once instead of 6 times. Another one is to find out which parts of the data are not really important and just leave those away [3]. There are different techniques for compressing images. The Discrete Hartley Transform is a real-valued transform closely related to the Discrete Fourier Transform of a real-valued sequence. It directly maps a real-valued sequence to a real-valued spectrum while preserving some useful properties of the Discrete Fourier Transform. DCT helps separate the image into parts (or spectral sub-bands) of differing importance (with respect to the image's visual quality). The DCT is similar to the Discrete Fourier Transform (DFT). It transforms a signal or image from the spatial domain to the frequency domain. The DCT input is an 8 × 8 array of integers. DCT has been applied in many international compression standards such as JPEG, MPEG and so on for its special advantages including: highly energy-compacting capability, transforming block by block as a result of parallel implementation and low memory requirement. However, blocking DCT is less of considerations on the correlations of inter-blocks and always results in blocking artifacts at low bit rate, both of these defects effect the rate distortion (RD) performance and visual quality of reconstructed images. DWT is also important as it is closely related to DFT or real valued signals.

1.1 Image

An image is the two dimensional (2-D) picture that gives appearance to a subject usually a physical object or a person. It is digitally represented by a rectangular matrix of dots arranged in rows and columns. A digital image is composed of pixels arranged in a rectangular array with a certain height and width. Each pixel may consist of one or more bits of information, representing the brightness of the image at that point and possibly including color information encoded as RGB triples.

1.2 Pixels

In digital imaging, a pixel, picture element [4] is a single point in a raster image, or the smallest addressable screen element in a display device; it is the smallest unit of picture that can be represented or controlled. Each pixel has its own address. The address of a pixel corresponds to its coordinates. Pixels are normally arranged in a two-dimensional grid, and are often represented using dots or squares. In color image systems, a color is typically represented by three or four component intensities such as red, green, and blue, or cyan, magenta, yellow, and black.

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1.3 Bits per pixels

The number of distinct colors that can be represented by a pixel depends on the number of bits per pixel (bpp). A 1 bpp image uses 1-bit for each pixel. Each additional bit doubles the number of colors available, so a 2 bpp image can have 4 colors, and a 3 bpp image can have 8 colors:

- 1 bpp, 21 = 2 colors (monochrome)
- **2** bpp, 22 = 4 colors
- 3 bpp, 23 = 8 colors
- 8 bpp, 28 = 256 colors
- 16 bpp, 216 = 65,536 colors ("Highcolor")
- 24 bpp, 224 ≈ 16.8 million colors ("Truecolor")

1.4 Redundancy

Data compression is essentially a redundancy reduction technique. It is the process of reducing the amount of data required to represent a given quantity of information. For the transmission of same amount of information, different amount of data might be used. If the same information can be represented using different amounts of data, and, the representations that require more data than actual information, is referred as data redundancy [5]. There are three kinds of redundancies that may present in the image.

I. Spatial redundancy

II. Spectral redundancy

III. Temporal redundancy

1.5 Data Compression

The data redundancies require large storage space. The compression can be achieved by reducing these redundant data is referred as data compression. Mathematically, by data compression means process of transforming pixel array of an image into statistically uncorrelated data set.

1.6 Principle of data compression

The main principle behind the image/data compression technique is to reduce the redundancy. In image compression methodology, generally spectral and spatial redundancy should be reduced as much as possible while for video compression, the temporal redundancy should be reduced. Image compression research aims to reduce the number of bits required to represent an image by removing the spatial and spectral redundancies as much as possible. If n1 and n2 denote the number of information carrying units in original and compressed image respectively, then the compression ratio CR can be defined as

$$\text{Compression Ratio} = \frac{\text{Discarded Data}}{\text{Original Data}}$$

CR=n1/n2;

And relative data redundancy RD of the original image can be defined as

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RD=1-1/CR;

1.7 Classification of data compression

The data compression techniques are mainly classified into two groups as follows:

I. Lossless compression technique

II. Lossy compression technique

1.2.1 Lossless compression technique

In the lossless data compression techniques, the original data can be exactly reconstructed as the original data. This type of compression techniques are generally used where the reconstruction quality is of the utmost importance, such as, executable programs, text documents, and source codes.

Some example of lossless compression techniques are:

a. Zip file format, and

b. Tiff image format

1.2.2 Lossy compression technique

The lossy compression techniques achieve data compression by losing some information while maintaining the reconstruction quality. Hence, the data cannot be reconstructed exactly as the original one. This is used for applications where low storage space and fast data transmission speed are needed while maintaining the acceptable reconstructed data quality. The examples of such applications are still image compression, video conferencing, internet telephony and so on. Some example of lossy compression techniques are as follows:

a. JPEG

b. JPEG 2000

II. DISCRETE HARTLEY TRANSFORM TECHNIQUE (DHT)

The Discrete Hartley Transform is a real-valued transform closely related to the Discrete Fourier Transform of a real-valued sequence. It directly maps a real-valued sequence to a real-valued spectrum while preserving some useful properties of the Discrete Fourier Transform. In such case, the Discrete Hartley Transform can act as an alternative form to the Fourier Transform for avoiding complex arithmetic; hence it becomes a valuable tool in digital signal processing. The Discrete Hartley Transform has received growing interest since it was introduced by Bracewell in 1983. One of the main attractions of DHT is that it only involves real computations in contrast to complex computations in the Discrete Fourier Transform [6]. The DHT for the signal block is $d\left[(j-n+1), d(j-n+2) ....d(j)\right]$ and given as follows [8]:

$$H(j.m)=\sqrt{\frac{1}{N}}\sum_{n=0}^{N-1} d(j-N+n+1)\left[\cos\left(\frac{2\pi nm}{N}\right)+\sin\left(\frac{2\pi nm}{N}\right)\right]$$
$$\text{for} \quad m=0,1.........,N-1$$

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Where *N* is the block length of the transform. For the case when the input signal is a stream of samples, *H* (*j. m*) are referred to as the running DCT's and DST's at time *n*. When a new sample *d* (*j+1*) becomes available, the signal block of interest shifts one sample in time to include *d* (*j+1*) and exclude *d* (*j-N+1*).

III. DISCRETE COSINE TRANSFORM TECHNIQUE (DCT)

DCT helps separate the image into parts (or spectral sub-bands) of differing importance (with respect to the image's visual quality).JPEG image compression standard use DCT (DISCRETE COSINE TRANSFORM). The discrete cosine transform is a fast transform. DCT is a widely used and robust method for image compression. It has excellent compaction for highly correlated data.DCT has fixed basis images DCT gives good compromise between information packing ability and computational complexity. The DCT is similar to the Discrete Fourier Transform (DFT): it transforms a signal or image from the spatial domain to the frequency domain. With an input image, A, the coefficients for the output image B. The input image is *N*2 pixels wide by *N*1 pixels high; *A*(*i, j*) is the intensity of the pixel in row '*i* and column '*j*; *B*(*k*1, *k*2) is the DCT coefficient in row *k*1 and column *k*2 of the DCT matrix. All DCT multiplications are real. This lowers the number of required multiplications, as compared to the DFT. The DCT input is an 8 × 8 array of integers. The output array of DCT coefficients contains integers; these can range from -1024 to 1023. For most images, much of the signal energy lies at low frequencies; these appear in the upper left corner of the DCT [6].
Let *x(n)* (n=0, 1,…..*N*-1) be a time domain data sequence and *y(k)* (k= 0, 1…….. *N*-1) be the corresponding transform-domain sequence. The Discrete Cosine Transform is defined:

$$y(k)=\sqrt{\frac{2}{N}}u(k)\sum_{n=0}^{N-1}x(n)\cos\frac{(2n+1)k\pi}{2N}$$
$$\text{for } \; k=0,1,.......N-1$$

and

$$x(n)=\sqrt{\frac{2}{N}}\sum_{k=0}^{N-1}u(k)y(k)\cos\frac{(2n+1)k\pi}{2N}$$
$$\text{for } \; n=0,1,.......N-1$$

where

$$u(k)=\begin{cases}\frac{1}{\sqrt{2}}, & \text{if } \; k=0\\ 1, & \text{otherwise}\end{cases}$$

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since $\sqrt{\frac{2}{N}}$ is a simple scaling of the input sequence, we ignore the scaling factor and consider the normalized DCT/IDCT computation. Equation (1) can be rewritten in matrix form as (y_N) *[*C_N*]*(x_N), where (x_N) and (y_N) are N- dimensional input and output column vectors, respectively, and (C_N) is the N *x* N DCT coefficient matrix where

$$[C_N]_{kn} = \begin{cases} \frac{1}{\sqrt{2}} & \text{if } k = 0 \\ \cos\frac{(2n+1)k\pi}{2N}, & \text{otherwise} \end{cases}$$
$$\text{for } k, n = 0, 1, \ldots\ldots\ldots N-1$$

IV. DISCRETE WAVELET TRANSFORM (DWT)

The wavelet transform decomposes the signal into a band of energy which is sampled at different rates. These rates are determined to maximally preserve the information of the signal while minimizing the sampling rates or the resolution of each subband.JPEG 2000 image compression standard makes use of discrete wavelet transform. DWT can be used to reduce the image size without losing much of the resolutions computed and values less than a pre-specified threshold are discarded. Thus it reduces the amount of memory required to represent given image. DWT employs two sets of functions, called scaling functions and wavelet functions, which are associated with low-pass and high-pass filters, respectively. After each filtering step, half of the samples can be eliminated according to the Nyquist's rule, since the signal now has a highest frequency of $\pi/2$ radians instead of π. The signal can therefore be subsampled by 2 simply by discarding every other sample. The four versions of the discrete Wavelet transforms (DWT's) are defined by [8] as follows:

DWT-1:
$$W_s, i(j.m) = \sqrt{\frac{2}{N}} \sum_{n=0}^{N_1} d(j - N + 1 + n)$$
$$\sin\left(\frac{\pi}{4} + nm\frac{2\pi}{N}\right)$$
$$m = 0.1, \ldots\ldots\ldots, N-1$$

DWT-II:
$$W_s\, ii(j.m) = \sqrt{\frac{2}{N}} \sum_{n=0}^{N-1} d(j - N + 1 + n)$$
$$\sin\left(\frac{\pi}{4} + m\left(n + \frac{1}{2}\right)\frac{2\pi}{N}\right)$$
$$m = 0.1, \ldots\ldots\ldots, N-1$$

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$$\text{DWT-III}: \quad W_s iii(j.m) = \sqrt{\frac{2}{N}} \sum_{n=0}^{N-1} d(j-N+1+n) \sin\left(\frac{\pi}{4} + n\left(m+\frac{1}{2}\right)\frac{2\pi}{N}\right)$$

$$m = 0.1, \ldots\ldots\ldots, N-1$$

$$\text{DWT-IV}: \quad W_s iv(j.m) = \sqrt{\frac{2}{N}} \sum_{n=0}^{N-1} d(j-N+1+n) \sin\left(\frac{\pi}{4}\left(n+\frac{1}{2}\right)\left(m+\frac{1}{2}\right)\frac{2\pi}{N}\right)$$

$$m = 0.1, \ldots\ldots\ldots, N-1$$

Where N is the block length of the transform. Note that the DWT-I is identical to the DHT. Hence we only need to consider the above DWT's definitions.

V. CONCLUSION AND DISCUSSION

Image compression study using combination of Discrete Hartley Transform, Discrete Cosine Transform and Discrete Wavelet Transform is studied on the different image. In this paper, combining the DHT, the DWT and the DCT algorithms under high compression ratio constraint for image compression has been presented. The analysis also showed that for the same compression ratio, the high value of PSNR is obtained by using the combination of DHT-DCT-DWT Transform. The study is intended to be used as the image compressor engine in imaging and applications where high compression is required.

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