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Image Compression Technique Using Hybrid Discreet Cosine Transform (DCT) and Discreet Wavelet Transform (DWT) Method

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Abstract: **As per the present scenario, the increasing growth of technology and the entrance into the digital age, we have to handle a vast amount of information every time which often presents difficulties. So, the digital information must be stored and retrieved in an efficient and effective manner, in order for it to be put to practical use. Compressing an image is significantly different than compressing raw binary data. General purpose compression programs can be used to compress images, but the result is less than optimal. In this paper, a novel scheme that combines the Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT) is proposed. DCT has high energy compaction property and requires less computational resources. On the other hand, DWT is multi-resolution transformation.**

Keywords — Compressing, Discrete Wavelet Transform, Discrete Cosine Transform

I. Introduction

In a digital true- color images, each color component is quantized with 8 bits, and so a color is specified with 24 bits. As a result, there are 2^24 possible colors for the image. Furthermore, a color image usually contains a lot of data redundancy and requires a large amount of storage space. In order to lower the transmission and storage cost, image compression is desired. Most color images are recorded in RGB model, which is the most well known color model. However, RGB model is not suited for image processing purpose. For compression, a luminance-chrominance representation is considered superior to the RGB representation. Therefore, RGB images are transformed to one of the luminance-chrominance models, performing the compression process, and then transform back to RGB model because displays are most often provided output image with direct RGB model[1].

A. Image Compression

The objective of image compression is to reduce irrelevance and redundancy of the image data in order to be able to store or transmit data in an efficient form. The best image quality at a given bit rate (or compression rate) is the main goal of image compression. The quality of a compression method often is measured by the Peak signal to noise ratio. It measures the amount of noise introduced through a lossy compression of the image[6].

Image compression can be of 2 types:

(i) Lossy
(ii) Lossless

Lossy compression:- 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.

Methods for lossy compression:

(i) Reducing the color space to the most common colors in the image
(ii) Chroma sub sampling
(iii) Transform coding
(iv) Fractal compression

Lossless compression: Lossless compression is preferred for archival purposes and often for medical imaging, technical drawings.

Methods for lossy compression:

(i) Run- length encoding
(ii) DPCM and Predictive Coding
(iii) Entropy encoding, chain codes etc[5].

B. Need of Color image compression

A color image usually contains a lot of data redundancy and requires a large amount of storage space. Multimedia content takes up a lot of storage space and bandwidth. A true color 512 x 512 image would take 0.75 Mbyte of space. In order to lower the transmission and storage cost, color image compression is desired [2].

II. Wavelet Transform

A wavelet is a wave-like oscillation with amplitude that starts out at zero, increases, and then decreases back to zero. It can typically be visualized as a "brief oscillation" like one might see recorded by a seismograph or heart monitor. A wavelet is a mathematical function used to divide a given function or continuous-time signal into different scale components. Usually one can assign a frequency range to each scale component. A wavelet transform is the representation of a function by wavelets.

Wavelet transform are of two types:

1.<u>Continuous wavelet transform</u>: In continuous wavelet transforms, a given signal of finite energy is projected on a continuous family of frequency bands. For instance the signal may be represented on every frequency band of the form [f, 2f] for all positive frequencies $f>0$. Then, the original signal can be reconstructed by a suitable integration over all the resulting frequency components.

2. <u>Discrete wavelet transforms</u>: It is computationally impossible to analyze a signal using all wavelet coefficients, so one may wonder if it is sufficient to pick a discrete subset of the upper half plane to be able to reconstruct a signal from the corresponding wavelet coefficients.

The Haar wavelet's mother wavelet function $\psi(t)$ can be described as

$$\Psi(t) = \begin{cases} 1 & 0 \le t \le 1/2, \\ -1 & \tfrac{1}{2} \le t \le 1, \\ 0 & \text{otherwise} \end{cases}$$

Its scaling function $\phi(t)$ can be described as

$$\phi(t) = \begin{cases} 1 & 0 \le t \le 1, \\ 0 & \text{otherwise} \end{cases}$$

Advantages of Haar Wavelet transform:

- Best performance in terms of computation time
- Computation speed is high
- Memory efficient
- Simplicity
- Easily implementable in hardware

For image compression, transform coding are of two types:

- 1. Discrete Cosine transform
- 2. Discrete Wavelet transform

In this paper, discrete haar wavelet transform is used which has following advantages over discrete cosine transform:

- DCT is used for transformation in JPEG standard whereas DWT is used for transformation in JPEG 2000 standard.
- DWT avoids blocking artifacts which degrade reconstructed images which DCT can't do.
- Compression increases with increase in window size for DCT and decreases with increase in window size for DWT.
- In DWT, the decomposition into subbands gives a higher flexibility in terms of scalability in resolution and distortion.
- DCT performs good at moderate bit rates whereas DWT performs good at moderate as well as low bit rates.

A. Haar Wavelet Transform

Haar wavelet transform (HWT) consists of both: low pass and high pass filters is the preferred wavelet because it can be readily implemented in hardware [7]. The approximation band (LL) is the result of applying low pass filter in vertical and result of applying low pass filter in vertical and applying horizontal low pass filter and vertical high pass filter, while the (HL) band is the result of horizontal high pass filter and vertical low pass filter and finally (HH) band is the result of horizontal and vertical high pass filter. In this transform each (2x2) adjacent pixels are picked as group and passed simultaneously through four filters (i.e., LL, HL, LH and HH) to obtain the four wavelet coefficients, the bases of these 4-filters could be derived as follows:

- $L = 1/\sqrt{2}\ (1 \quad 1)$
- $H = 1/\sqrt{2}\ (1 \quad -1)$
- LL= vertical LPF+ horizontal HPF

$$LL = 1/2 \begin{pmatrix} 1 & 1 \\ 1 & 1 \end{pmatrix}$$

- HL= horizontal HPF+ vertical LPF

$$HL = 1/2 \begin{pmatrix} 1 & 1 \\ -1 & -1 \end{pmatrix}$$

- LH= horizontal LPF+ vertical HPF

$$LH = 1/2 \begin{pmatrix} 1 & -1 \\ 1 & -1 \end{pmatrix}$$

- HH= horizontal HPF+ vertical HPF

$$HH = 1/2 \begin{pmatrix} 1 & -1 \\ -1 & 1 \end{pmatrix}$$

If we apply forward (HWT) on test color image (e.g., luminance component),at the beginning of decomposition, the image will be divided into four sub-bands LL, HL, LH, and HH , this procedure defines first level sub-band coding, while divided sub-band LL of first level into four sub-bands defines second level, and divided sub-band LL of second level into four sub-bands defines third level . To reconstruct the image, the same four two dimensional filters have been used [3].

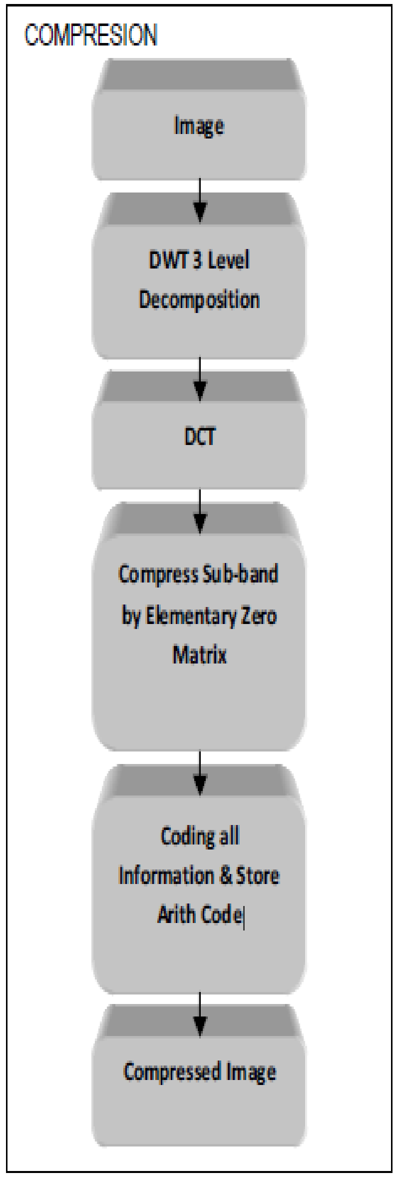

Figure 1. Flow chart for image compression

B. Discrete Cosine Transform

The discrete cosine 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: it transforms a signal or image from the spatial domain to the frequency domain. A discrete cosine transform (DCT) expresses a sequence of finitely many data points in terms of a sum of cosine functions oscillating at different frequencies. DCTs are important to numerous applications in science and engineering, from lossy compression of audio (e.g. MP3) and images (e.g. JPEG) (where small high-frequency components can be discarded), to spectral for the numerical solution of partial differential equations. The use of cosine rather than sine functions is critical in these applications: for compression, it turns out that cosine functions are much more efficient (as described below, fewer are needed to approximate a typical signal), whereas for differential equations the cosines express a particular choice of boundary conditions. In particular, a DCT is a Fourier-related transform similar to the discrete Fourier transform (DFT), but using only real numbers. DCTs are equivalent to DFTs of roughly twice the length, operating on real data with even symmetry (since the Fourier transform of a real and even function is real and even), where in some variants the input and/or output data are shifted by half a sample. There are eight standard DCT variants, of which four are common [4].

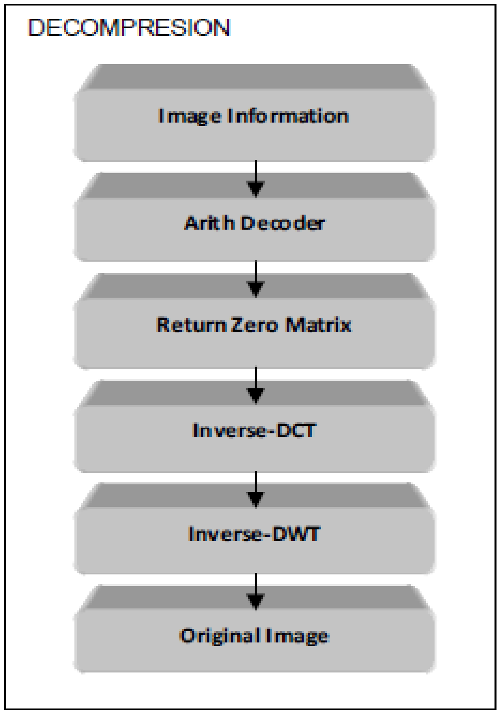

Figure 2 Flow chart for image decompression

III. Simulations and Result

This section evaluates the performance of the proposed hybrid DWT-DCT algorithm. The proposed hybrid algorithm is applied on several types of images: natural images, medical images, benchmark images such that the performance of proposed algorithm can be verified for various applications. The retrieve image is also shown.

Figure 3 Original image

Figure 4 Compressed image using DWT (Haar wavelet)

Figure 5 Reconstructed image using DWT (Haar wavelet)

Figure 6 Hybrid compression using DWT (HAAR wavelet) & DCT

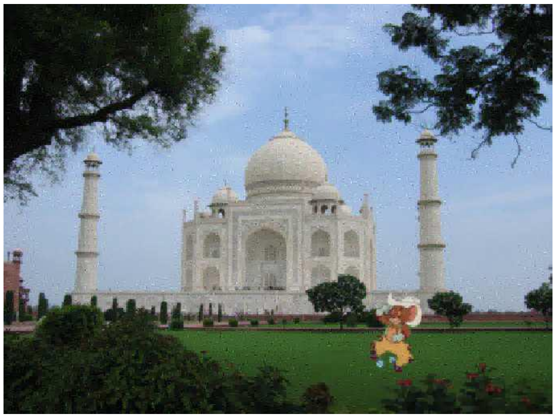

Figure 7 Hybrid Decompression using DWT (HAAR wavelet) & DCT

Table I Compression ratio:

Method	CR(hard threshold)	CR(soft threshold)
DWT	15.74	14.1
DCT	17.11	15.87
Hybrid DWT-DCT	18.17	16.95

IV. Conclusions

In this paper, a hybrid scheme combing the DWT and the DCT algorithms under high compression ratio constraint for image has been presented. It was observed that the proposed algorithm has better performance as compared to the other stand alone algorithms. Moreover, the proposed algorithm was also compared with some standards and already developed hybrid algorithms. It was observed that the proposed hybrid algorithm performs better than the existing algorithms. The proposed scheme is intended to be used as the image compressor applications where high compression is required.

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Tutorials:

(i) THE WAVELET TUTORIAL PART I by ROBI POLIKAR
(ii) THE WAVELET TUTORIAL PART II by ROBI POLIKAR
(iii) THE WAVELET TUTORIAL PART III by ROBI POLIKAR
(iv) THE WAVELET TUTORIAL PART IV by ROBI POLIKAR

