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DUAL TREE COMPLEX WAVELET TRANSFORM BASED IMAGE COMPRESSION USING THRESHOLDING

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ABSTRACT

Large size images consist of multiple bands data which occupies large space. Image compression becomes important for such large image or data's to reduce the bandwidth in transmission over a network and in storage space. Wavelet transform is an efficient tool with some limitations for various image processing applications. And these limitations are overcome by complex wavelet transform. In this paper dual tree complex wavelet transform is implemented based on arithmetic encoding algorithm. Dual tree complex wavelet transform (DTCWT) brings wavelet co-efficient nearer to zero. Also thresholding generates more zeros to yield higher compression ratio for an image compression with high quality image. Arithmetic coding algorithm is employed in this proposed method to improve compression ratio for compression of an image or data. The proposed method is implemented in MATLAB and the experimental result is compared with DCT Arithmetic and Huffman coding. The proposed method yields compression ratio of 3.6312 which is 33% and 24.03% higher than DCT using Arithmetic and Huffman coding respectively.

Keywords: dual tree complex wavelet transform, image compression, arithmetic encoding.

1. INTRODUCTION

Complex images [1] and digital photographs in colour images generate massive size for file and occupy more storage space. Transmissions of data over internet and across networks face this storage issues. While transferring uncompressed image over network may slow down the process, need more time, data's may be lost or even quality of the image may be affected. This may degrade (i.e. quality of the image or data) the overall performance of the system process. Inorder to overcome from this degradation, the physical file size of the image or data must be reduced with unchanged in quality and this lead to develop an Image compression technique [12], [13]. Now-a-days many images have undergone image compression which increases the speed in upload/download of data or image on internet which minimizes the space and bandwidth without change in quality of image [9], [14], [15] physical size or data's. Image Compression is widely used by web designers to create sites with rich image by occupying less storage space and avoid unwanted bandwidth.

Image compression helps end users in sending/receiving images or uploading/downloading data's faster on slower devices and also make others to access friendly. There are many techniques [8], [9] like lossy or lossless in image compression. In lossy compression technique some information are lost. Lossless compression yields effective compression ratio [2] after compression with the reconstructed image identical to original image [11]. Compression of an image mainly involves thresholding and entropy coding. There are two types of thresholding namely, hard and soft thresholding [16], [18]. Encoding is done by entropy coding in which arithmetic and Huffman coding [7] are frequently used. Arithmetic coding performs with higher compression ratio than Huffman coding. Wavelet transform [17] is an efficient tool with some limitations [10] for various image processing applications. To obtain an image or data with higher compression ratio in lossless compression Complex Wavelet Transform (CWT) technique is widely implemented which reduces the memory space. It offers multi resolution of 2D wavelet transform.

In this paper dual tree complex wavelet transform (DTCWT) is implemented with arithmetic entropy encoding algorithm in hard thresholding for image compression using MATLAB to increase the compression ratio. A 16 bit image is used for image compression. DTCWT use two separate Discrete Wavelet Transforms to calculate complex transform.

2. RELATED WORK

Directional lifting wavelet transform (DLWT) [Xingsong Hou *et al.*, 2013] was proposed for compressing complex synthetic aperture radar (SAR) image which consists of real and imaginary parts, in which first step encodes both parts by CCSDS algorithm and second step converts complex image into real image by FFT. This scheme has improved performance gain in PSNR and in MPE. Context-Based Entropy Coding of Block Transform Coefficients [Chengjie Tu and Trac D. Tran, 2002] consists of local CEB (L CEB) and embedded CEB (E CEB), where L CEB quantizes, transforms and compresses image block by block sequential without buffer and E CEB compresses image bit plane by bitplane like progressive coders for better compression at high bit rates.

A new denoising algorithm was proposed (M. Kıvanc Mıhcak *et al.*, 1999) in two steps, first posteriori (MAP) was utilized to estimate variance for each coefficient using noisy data observed in a local neighborhood and second the estimator value is substituted for variance to find out MMSE which restore the noisy wavelet image coefficients and proved as best. Many types of thresholding was discussed in this paper [Iain M. Johnstone and Bernard W.

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Silverman, 1996] and considered the problems in error with general correlation structure and derived the methods with wavelet threshold estimators applicable to noise processes with both short and long range dependence. A different context modeling and selection techniques (V. N. Ramaswamy *et al*., 2001) for efficient entropy encoding of wavelet coefficients with modified SPIHT algorithm was performed. Several experiments were done to insist the importance of context modeling using embedded zero tree wavelet (EZW) which improves the performance of compression even in multilevel sub-band decomposition.

An adaptive sampling algorithm with discrete cosine transform (Yung-Gi Wu, 2002) was implemented on spectral domain to illustrate the need for data compression to reduce the storage space and ease for transmission and to retrieve the compressed data linear equation was employed in decoder which is straight forward and simple, moreover implementation in hardware was easy. The need and importance of quality metrics (Zhigang Gao and Yuan F. Zheng, 2008) on image quality after compression were discussed by the authors and proposed a new metric named weighted normalized mean square error of wavelet subbands (WNMSE) and a compression algorithm called quality constrained scalar quantization was developed based on quantization steps, statistic features and WNMSE values of image.

3. PROPOSED METHODOLOGY

A gray scale image is selected for compression. Initially the original image is decomposed by applying Dual Tree Complex Wavelet Transform. The coefficients obtained are modified by threshold for further compression using arithmetic encoding in entropy process. Compression ratio is obtained from the compressed image.

3.1 Dual Tree Complex Wavelet Transform (DTCWT)

An efficient tool in image processing is Wavelet transform which finds its application in motion estimation, data compression, denoising, segmentation and classification areas. In spite of its limitations such as Shift sensitivity, Lack of directional selectivity and Lack of phase information, it is not employed in many fields. Dual Tree Complex Wavelet Transform (DTCWT) overcomes these above said limitations and is shown in Figure-1. It uses two separate discrete wavelet transform (Tree a, Tree b) with low pass and high pass sub band filters, to calculate complex signal transform. Two DWT's can produce real and imaginary coefficients separately, if only, both the filters are designed specifically different from one another. Upper DWT produces real part while lower DWT produces imaginary part. If both are same there is no gain. The implementation has two steps. First, decomposition of an input image is done by two branches 'a' and 'b' where upper DWT is Hilbert transform (approximate) linked with lower DWT. Second, same pass bands of corresponding two sub bands are combined linearly either by differencing or averaging.

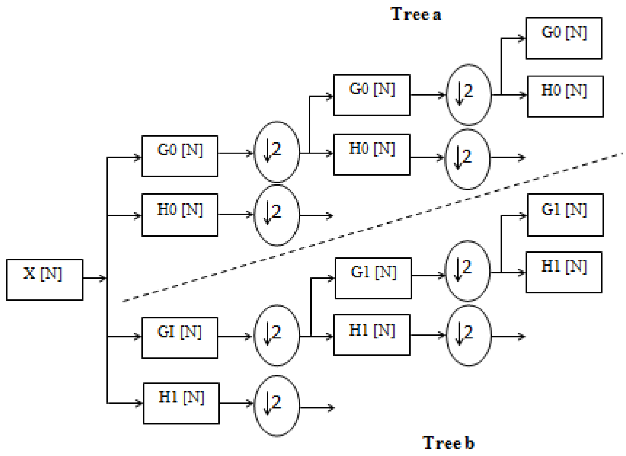

Figure-1. Dual Tree Complex Wavelet Transform.

3.2 Image Compression

Image or data compression is necessary in transmission or storage of an image or information. To be compressed, image can be represented in smaller number of bits. To achieve good compression various compression techniques have been developed. One among them is DTCWT, is applied to the input image which brings the coefficients closer or equal to zero. In addition, threshold also generates more zeros. The threshold value λ is set and the value below λ is set to zero to generate more zeros in hard thresholding, which in turn requires less space for storage and using entropy coding transmission becomes more quickly. Entropy coding is done by arithmetic coding to compress the image. The block diagram using DTCWT for compression is shown in Figure-2.

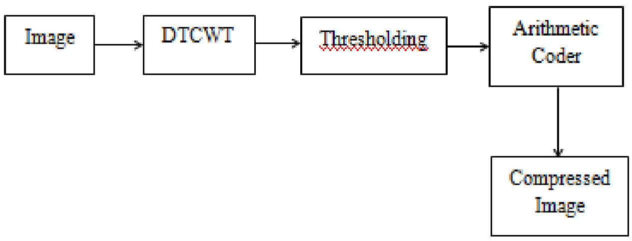

Figure-2. Block diagram using DTCWT for compression.

3.3 Arithmetic coding

Encoder process is one of the essential steps in compression. Image decomposition into sequence of events and encoding the events as bits is the basic problem in lossless compression. Arithmetic coding replaces Huffman coding in recent years for its better compression ratio and performance for data compression. In this paper arithmetic coding is used in which input symbol is replaced by a specific code in a file or message and this specific code is represented by an integer number ranges between 0.0 and 1.0 of real number. Short and long code words are assigned to more and less probable events respectively. This statistic becomes accurate when the result of coding reaches Shannon's entropy limit for input symbols in large sequence. Arithmetic coding consists of three registers as low, high and range.

Range = High – Low + 1

High = Low + Range * $\frac{CUM\_FREQ[i-1]}{CUM\_FREQ[0]}$

Low = High + Range * $\frac{CUM\_FREQ[i]}{CUM\_FREQ[0]}$

$CUM\_FREQ[i]$ denotes the cumulative frequency or count of the symbol 'I'.

Data compression takes place when some events are similar with others.

3.4 Compression Algorithm

The steps involved for image compression

a) Fetch input image.
b) Image decomposed into wavelet coefficients using DTCWT.
c) Thresholding - modification of coefficients.
d) To compress an image using arithmetic coding.
e) Calculate the compression ratio.

4. SIMULATION RESULT

The input image of size 256x256 shown in Figure-3 is implemented using dual tree complex wavelet transform method with arithmetic coding for compression. Table-1 shows the comparison of compression ratio and execution time for DCT using Huffman and Arithmetic coding with the proposed method DTCWT using Arithmetic coding. It is illustrated that compression ratio of the proposed method yields good compression ratio of 3.6312 while DCT using Huffman coding and Arithmetic coding yields 4.78 and 5.40 respectively. The execution time taken by Huffman and Arithmetic coding in DCT technique was 0.55 and 1.63 seconds respectively, while execution time for the proposed method is 7.5 seconds. More time is needed to execute Arithmetic coding with high compression ratio. The compressed output image is shown in Figure-4. Figure-5 shows the Comparison of compression ratio for different methods.

Figure-3. Input image

Figure-4. Output image.

Table-1. Comparison of compression ratio and execution time.

Parameters	DCT using Huffman coding [19]	DCT using Arithmetic coding [19]	DTCWT using Arithmetic coding
Image size 256x256	4.78	5.40	3.6312
Execution time (in Seconds)	0.55	1.63	7.5

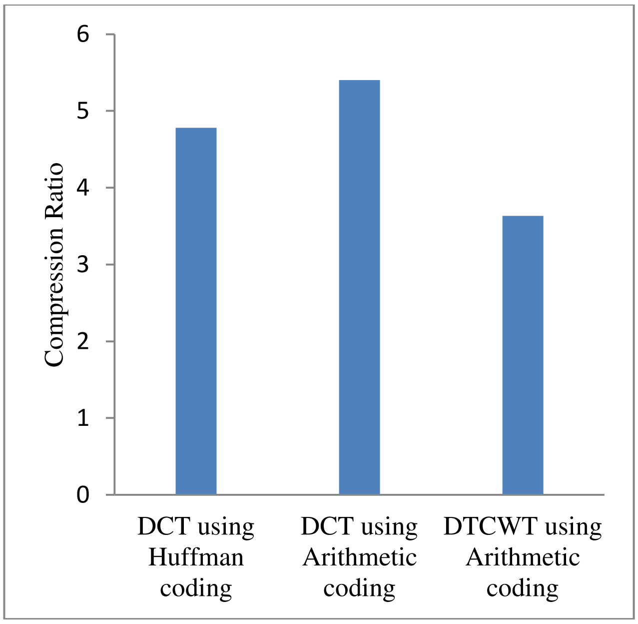

Figure-5. Comparison of compression ratio for different methods

5. CONCLUSIONS

Compression becomes essential in this computing field to reduce the data or image size in faster transmission and minimum space for storage than uncompressed data or image. Many techniques are designed for image compression and for entrophy coding in thresholding. Arithmetic and Huffman algorithms are mostly used in entropy coding. In this paper dual tree complex wavelet transform is implemented using arithmetic coding algorithm is used for entrophy coding in hard thresholding. The proposed method is the better with high compression ratio of 3.6312 compared with DCT using Huffman and Arithmetic algorithm, is shown in Table-1. The proposed method is 33% higher in compression ratio compared with DCT with Arithmetic coding and 24.03% higher compression ratio compared with DCT with Huffman coding.

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