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Medical Image Compression Using Dual Tree Complex Wavelet Transform and Arithmetic Coding Technique

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ABSTRACT

Modern medical image diagnostic are often based on X-ray, computerized tomography and magnetic resonance imaging technique. The raw data delivered by such imaging devices more often than not take several mega-bytes of disk space. The diagnostic images for radiology interpretation must be efficiently stored and transmitted by physician for the further medical or legal purposes. Digital medical image processing generates large and data-rich electronics files. To speed up the electronic transmission and to minimize computer storage space, medical images are often compressed into files of smaller size. Compressed medical images have to protect all the original data details when they are restored for image presentation. The paper propose the dual tree wavelet transform and arithmetic coding technique of medical image compression. The dual-tree complex wavelet transform (CWT) is a relatively recent enhancement to the discrete wavelet transform (DWT), with important additional properties, it is nearly shift invariant and directionally selective in two and higher dimensions. And arithmetic coding is a common algorithm used in both lossless and lossy data compression algorithm. It protects all the key image information needed for the storage and transmission. Image compression is required to minimize the storage space and reduction of transmission cost.

Keywords: Medical Image Compression, DTCWT & Arithmetic Coding.

I. INTRODUCTION

A compression of medical imagery is an important area of biomedical and telemedicine. For the medical application image study and data compression are quickly developing field with rising applications services are teleradiology, teleconsultation, biomedical, telemedicine and medical data analysis. Image compression is required to minimize the storage space and reduction of transmission cost.

The complexity involved in the processing of the medical images significantly differs from that of ordinary images. The ordinary natural scene images are taken from generic digital image capturing devices, while the medical images are captured from a sophisticated image capturing devices.

In medical image compression diagnosis and analysis are doing well simply when compression technique protects all the key information needed for the storage and transmission. Depending on whether the reconstructed image has to be exactly same as the original or some unidentified loss may be incurred.

Data compression tries to reduce the size of the image by focusing on the removal of redundant data. Storage area of the image is doubled by compressing an image into half its original size. In other words, image compression by removing the spatial and spectral redundancies significantly reduces the number of bits required to present an image. Compression is achieved by removing one or more of the three basic data redundancies:

1) The Coding redundancy, which is present when less then optimal code words are used;

2) Inter pixel redundancy, which results from correlation between pixels of an image.
3) Psycho visual redundancy, which is due to the data that are ignored by the human visual system.
Two techniques for compression exist. The first one is lossless compression and the second one is lossy compression. Although lossy compression technique achieve very high compression ratios but the decompressed image is not exactly same as the original one. These methods take the advantage of the fact that to certain extent the human eye cannot differentiate between the images although noise exists in the decompressed image. Lossless methods on the other hand, give very less compression ratios but exactly recover back the original image.

Another approach is the hybrid approach to compression. It incorporates lossy as well as lossless compression. Various parts of image are compressed in either way, depending on the amount of information held in that part. it's the combination of different medical image compression methods.

This paper is organized as follows: This paper is organized as follows: the first section introduces the introduction part, the second section holds the brief description of the methods used in this paper for medical image compression, section third consist the mathematical comparison parameter, fourth section represents the simulation result fifth section concludes the summary of the paper and sixth and last one has the references.

II. METHODS AND MATERIAL

1. Compression Methodology

Dual Tree Comlex Wavelet Transform

The dual-tree complex wavelet transform (CWT) is relatively recent enhancement to the discrete wavelet transform(DWT), with important additional properties: It is nearly shift invariant and directionally selective in two and higher dimensions. It achieves this with a redundancy factor of only 2d for d-dimensional signals, which is substantially lower than the un-decimated DWT. The complex wavelet transform (CWT) is a complex-valued extension to the standard discrete wavelet transform (DWT). It is two-dimensional wavelet transform which provide multi resolution, sparse representation, and useful characterization of the structure of an image. The dual-tree complex wavelet transform (DTCWT) calculates the complex transform of a signal using two separate DWT decompositions (tree *a* and tree *b*). If the filters used in one are specifically designed different from those in the other it is possible for one DWT to produce the real coefficients and the other the imaginary.

One effective approach for implementing an analytic wavelet transform, first introduced by Kingsbury in 1998, is called the dual-tree CWT. Like the idea of positive/negative post-filtering of real sub-band signals, the idea behind the dual-tree approach is quite simple. The dual-tree CWT employs two real DWTs; the first DWT gives the real part of the transform while the second DWT gives the imaginary part.

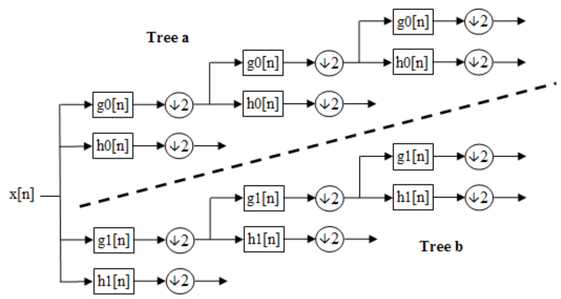


Figure 1. Dual tree complex Wavelet Transform

The **complex wavelet transform (CWT)** is a complex valued extension to the standard discrete wavelet transform (DWT). It is a two-dimensional wavelet transform which provides multi resolution, sparse representation, and useful characterization of the structure of an image. Further, it purveys a high degree of shift invariance in its magnitude, which however, a drawback to this transform is that it is exhibits (where is the dimension of the signal being transformed) redundancy compared to a separable (DWT).

ADVANTAGES

1. It provides the contour edge maintenance.
2. Provides both real and imaginary coefficients.

Arithmetic Coding Technique

Arithmetic coding is a common algorithm used in both lossless and lossy data compression algorithm. It is an entropy encoding technique in which the frequently seen symbols are encoded with fewer bits than rarely seen symbols. Arithmetic coding offers a way to compress data and can be useful for data source having a small alphabet. The length of arithmetic code, instead of being fixed relative to the no. of symbol being encoded, depends on the statistical frequency with which the source produces each symbol from its alphabet. For long sequence from source having skewed distributions and small alphabets, arithmetic coding compress batter than Hoffman coding.

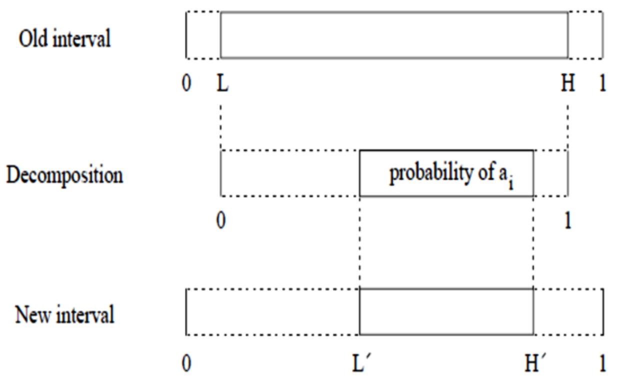


Figure 2. Arithmetic Coding Scheme

The most important advantage of arithmetic coding is its flexibility; it can be used in conjunction with any model that can provide the sequence of any event probabilities. The models used for arithmetic coding may be adaptive and in fact a no. of independent model may be used in succession in coding a single file. There is the cost associated with the flexibility : the interface between the model and the coder, while simple places considerable time and space demands on the models data structures especially in case of multi symbol input alphabet.

The other important advantage of arithmetic coding is its optimality. Arithmetic coding is optimal in theory and very nearly optimal in practices, in the sense of encoding using minimal average code length. This optimality is often less important than it might seem. When the probability of some single symbol is closer to 1, however, arithmetic coding does give considerably better compression than other methods.

In general, arithmetic coders can produce near-optimal for any given set of symbols and probabilities (the optimal value is $-\log_2 P$ bits for each symbol of probability P) compression algorithms that use arithmetic coding start by determining a model of the data-basically a prediction of what patterns will be found in the symbols of the message. The more accurate this prediction is, the closer to optimal the output will be.

One advantage of arithmetic coding over other similar methods of data compression is the convenience of adaptation. Adaption is the changing of the frequency (or probability) tables while processing the data. The decoded data matches the original data as long as the frequency table in decoding is replaced in the same way and in the same step as in encoding. The synchronization is, usually, based on a combination of symbols occurring during the encoding and decoding process.

Advantages of Arithmetic Coding:

1. Flexibility- it can be used in conjunction with any model that can provide the sequence of any event probabilities.
2. Optimality- encoding using minimal average code length.

2. Comparison Parameters

The various comparison parameters associated with medical image compression are as follows:

PSNR:
PSNR represents the measure of the peak error. Higher the PSNR value, batter the quality of compressed image.

MSE:
MSE represents the cumulative squared error between the compressed and original image. Lower the MSE lower is the error.

Compression ratio:
It is defined as the ratio of the size of the original image to the size of the compressed image.

CR=(Original image /Compressed image)

SSIM:
SSIM is the structure similarity index for measuring the similarity between the original image and compressed image.

III. RESULTS AND DISCUSSION

The medical image compression is implemented in the MATLAB version R2015a. Here the six medical test images are simulated by using the dual tree complex wavelet transform and the arithmetic coding technique. Whose tabulation form is represented in the table 4.1 .which gives the value of the different parameters of comparison.

And the comparison with other methods of image compression is also presented through the graphical representation. That is tabulated in the table 4.2 as follows.

Table 4.1

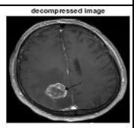
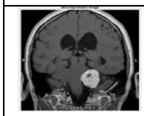
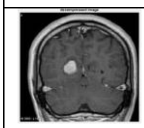
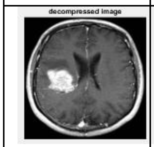
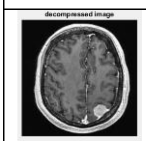
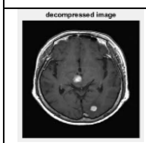
Medical Image	**PSNR**	**MSE**	**CR**	**image is compressed by**	**SSIM**
	75.09	26.55	1.97	49.2%	1.00
	66.87	28.47	2.84	64.7%	0.93
	63.81	28.88	2.15	53.6%	0.93
	55.13	28.6	2.17	54%	0.95
	56.85	27.63	2.57	61%	0.83
	74.09	23.31	2.24	55.4%	0.85

Table 4.2

NAME OF METHDO	PSNR value
Joint 3D DWT and SPIHT based algorithm	39.2
Irreversible wavelet compression	51.3
Hybrid DWT,DCT & Huffman coding	40
Region based lossless compression	43
Discrete Fractional Fourier transform	37
Dual tree discrete wavelet transform	40
Dual tree complex wavelet transform and Arithmetic coding technique	**65.30**

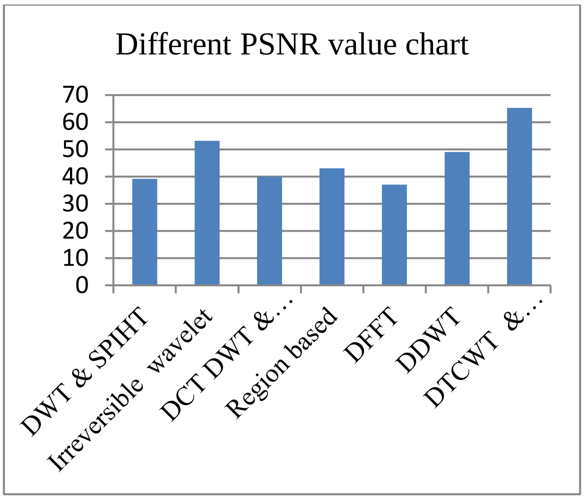


Figure 1: PSNR value chart of different methods

NAME OF METHDO	CR
ROI extraction and compression	1.6
LHT & Hoffman coding	1.94
Dual tree complex wavelet transform and Arithmetic coding technique	**2.32**

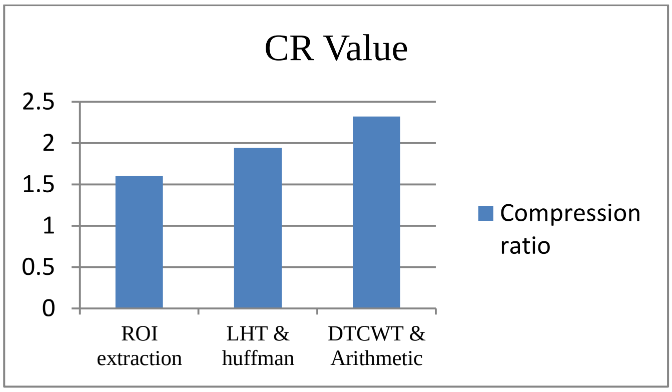


Figure 2: compression ratio value chart of different methods

IV.CONCLUSION

This paper provides the medical image compression by the dual tree complex wavelet transform and arithmetic coding technique. The compression is performed on the different MRI test image of the brain and the average PSNR value obtained is 65.30 with the low MSE 27.24

which is relatively higher than the other studied method. The average compression ratio is 2.32 and the structure similarity index is 0.915 for the test images. From this data we can say that the dual tree complex wavelet transform is the most efficient method for the image compression technique among DWT & SPIHT, Irreversible wavelet compression, DWT,DCT & Huffman, DFFT, LHT & Huffman etc.

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