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Progressive embedded lossless medical image compression using biorthogonal wavelet transform

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Abstract

In this paper we offers lossless compression method of medical images using biorthogonal wavelet transform based on embedded zero tree wavelet. Wavelet transforms offers wide space for image coding because of its excellent space frequency location. Efficient image compression solution one becoming more critical with the recent growth of data, multimedia based web application. Biorthogonal wavelets base can be constructed freely according to the wavelet performance, and it can quickly the implementations speed of the wavelet transform. The experimental results indicates that the biorthogonal wavelet has good performance with EZW.

Key word: Wavelet transforms: biorthogonal; image compressions; EZW.

1. Introduction

In two-dimensional image there exist many compression techniques such as JPEG, BMP, GIF and the new wavelet based PEG 2000 standard. All schemes above are used for two- dimensional images. In medical image compression, diagnosis is effective only when compression techniques preserve all the relevant information needed without any appreciable loss of information, in case with lossless compression. Lossy compression techniques are more efficient in terms of storage and transmission needs because of high compression ratio and the quality[1,2]. In lossy compression, image characteristics are usually preserved in the coefficients of the domain space in to which the original image is transformed. The quality of the image after compression is very important and it must be within the tolerable limits which vary from image to image and method to method, hence the compression becomes more interesting as a part of qualitative analysis of different types of medical image compression techniques[3,4,5].

Wavelet Transform (WT) represents an image as a sum of wavelet functions with different locations and scales. Basis for wavelet transform can be composed of any function that satisfies requirements of a multiresolution analysis, it means that there exits a large selection of wavelet families depending on the choice of wavelet function. A popular method of image compression is the embedded zero tree wavelet. The EZW encoder is based on a progressive encoding to compress an image into a bit stream with increasing accuracy. This means that when more bits are added to the stream, the decoded image will contain more detail.[6,7,8,9,10].

2. *Wavelet Compressions:*

Wavelet compression is a form of data compression well suited for image compression. The goal is to store image data in a little space as possible in a file wavelet compression can be either lossless or lossy.

Wavelet are mathematical functions that cut up data into different frequency components and then study each component with a resolutions matched to its scale. They have advantages over traditional Fourier methods in analyzing physical situations where the signal contains discontinuation and sharp spikes. An important property of wavelet functions in image compression applications is compact support. In this paper, we consider Haar Daubechies 4, Syamlet, Biorthogonal wavelet [11,12,14].

Biorthogonal Wavelet Transform:

A biorthogonal wavelet associated wavelet transform is invertible but not necessarily orthogonal. Designing biorthogonal wavelets allows more degree of freedom than orthogonal wavelets. One additional degree of freedom is the possibility to construct symmetric wavelet functions.

In the biorthogonal case, there are two scaling functions $\phi, \tilde{\phi}$, which may generate different multiresolution analyses, and accordingly two different wavelet functions $\psi, \tilde{\psi}$. So the numbers M, N of coefficients in the scaling sequences $a, \tilde{a}$ may differ. The scaling sequences must satisfy the following biorthogonality condition. Image compression and decompression of wavelet transforming using biorthogonal is shown[13] in figure 1.

$$\sum_{n \in Z} a_n \tilde{a}_{n+2m} = 2 \cdot \delta_{m,0}$$

Then the wavelet sequences can be determined as $b_n = (-1)^n \tilde{a}_{M-1-n}$, $n = 0,...,M-1$ and

$$b_n = (-1)^n a_{M-1-n}, \quad n = 0,....,N-1$$

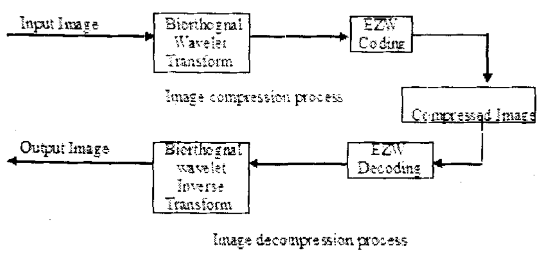


Figure 1. Image compression and decompression of wavelet transform.

Lossless compression :

The tree structure of the 3 level wavelet decomposition Figure 2 shows, a sub-tree taking a coefficient in sub-band HH3 as the root node is demonstrated. If the coefficient (i, j) in sub-band HH3 is root node, the 4 coefficients in HH2 $\{2i+m, 2j+n\}$, her $0\leq m, n\leq 1$, will be the child node, and the 16 coefficients in HH1 $\{4i+m, 4j+n\}$, here $0\leq m, n\leq 3$, will be the grandson node. There are 21 coefficients in a 3 level decomposition tree, and 20 coefficients are the grandson nodes of the root node. If a k (k=1, 2, 3, ...) level wavelet decomposition is made, there will be grandson nodes belonging to the root node in sub-band HHk.

$$\sum_{i=1}^{K-1} 4^{i} = 4/3\,(4^{k-1}-1)$$

The scanning order in the improved method begins from the high frequency coefficient of the last level rather than the low frequency coefficient. As Figure 3 shows, the scanning sequence is firstly high frequency in horizontal direction and low frequency in vertical (LHi) (i=3), then low frequency in horizon and high frequency in vertical(HLi), and then high frequency in diagonal(HHi), others are (LHi-1), (HLi-1), (LH1), (HL1), (HH1)[16,17].

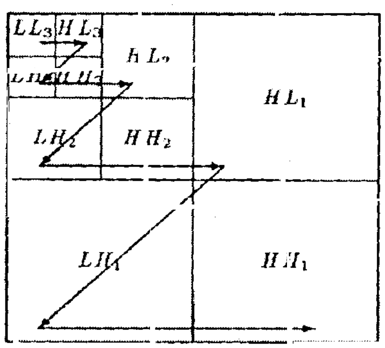


Figure 2. The tree structure of the 3 level wavelet decomposition

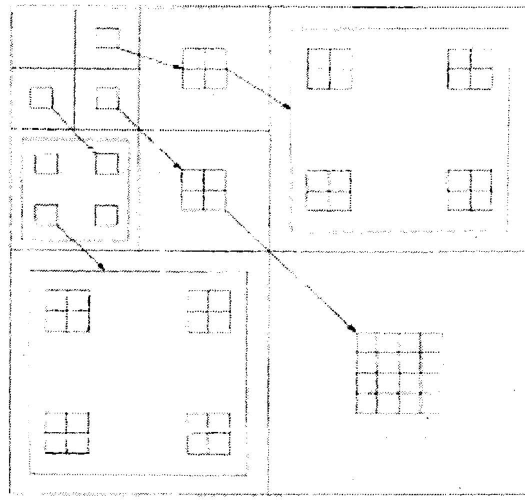


Figure 3. Parent-Child Dependencies of Subbands

Embedded zero tree wavelet coding ·

EZW encoder is based on a progressive encoding to compress an image into a bit stream with increasing accuracy. When more bits are added to the stream, the decoded image contains more details of the image. Coding an image using the EZW scheme, together with some optimizations, results in a remarkably effective image compressor with the property that the compressed data stream can have any bit rate desired. Any bit rate is only possible if there is information loss somewhere so that the compressor is lossy. However, lossless compression is also possible with an EZW encoder, with less optimal results. The design unit implements the EZW coding system for data compression The coding system reads the multiresolution component of the image obtained from the transformation module and passes the data to the decoder unit to retrieve the image back.

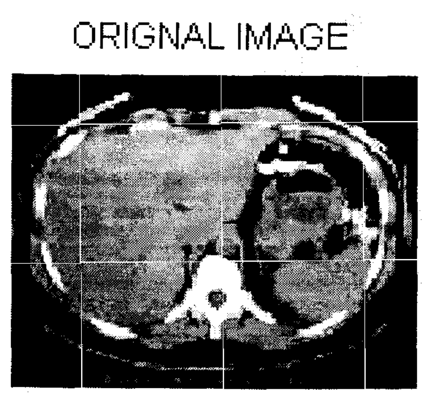
Before the processing of image data the images are preprocessed to improve the rate of operation for the coding system. Under preprocessing tiling on the original image is carried out. The term "tiling" refers to the partition of the original image into rectangular non overlapping blocks, which are compressed independently, as though they were entirely distinct images. All operations, including component mixing, wavelet transform, quantization and entropy coding are performed independently on the image tiles. Tiling reduces memory requirements, and since they are also reconstructed independently, they can be used for decoding specific parts of the image instead of the whole image. All tiles have exactly the same dimensions, except maybe those at the boundary of the image. Arbitrary tile sizes are allowed, up to and including the entire image. This unit transforms the input image from time domain to frequency domain and decomposes the original image into its fundamental components.

The wavelet transform uses filter banks for decomposition of preprocessed original image into 3 details and 1 approximate coefficient. The filtering is carried out by convolving the input image with the filter coefficients passed. EZW encoder encodes the decomposed image by recognizing the priority of decomposed image pixel. The encoder module calculates a initial threshold for coding given by $T_0 = 2^{\wedge}(\log_2 x_{max})$. The encoding process is performed using 2 passes namely dominant pass and subordinate pass. The dominant pass scans the coefficient using the threshold and assigned each coefficient with a symbol. Basically therefore isolated symbols for coding, they are positive significant (PS), negative significant (NS), isolated zero (IZ) and zerotree root (ZR). The other pass made at the encoding unit is the subordinate pass where the coefficients are encoded as 0 or 1 depending on the current threshold. These passes are repeated for n cycles reducing the current threshold by 2 until the required data bit rate is reached.

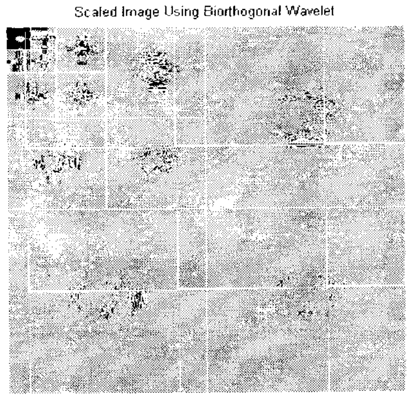
The decoding unit reconstructs the values by identifying the symbols as positive, negative, zerotree and isolated zerotree. Inverse transformation is the process of retrieving back the image data from the obtained image values. The image data transformed and decomposed under encoding side is rearranged from higher level decomposition to lower level with the highest decomposed levels arranged at the top[6,8,15].

Experimental results:

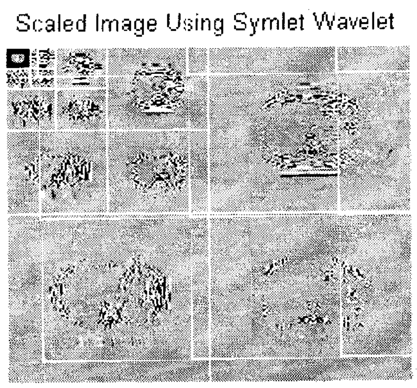
Original Image



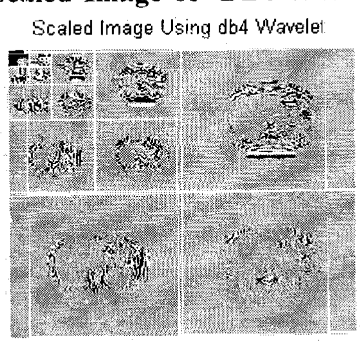
Scaled Image of Biorthogonal Wavelet



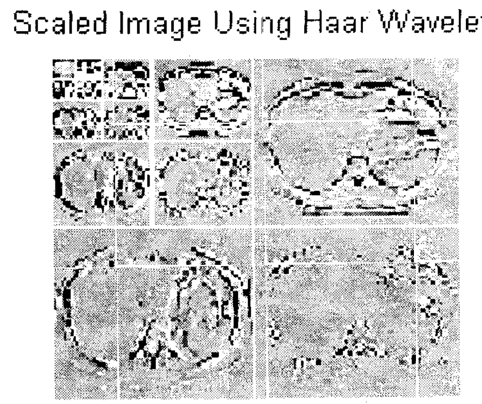
Scaled Image of Symlet Wavelet



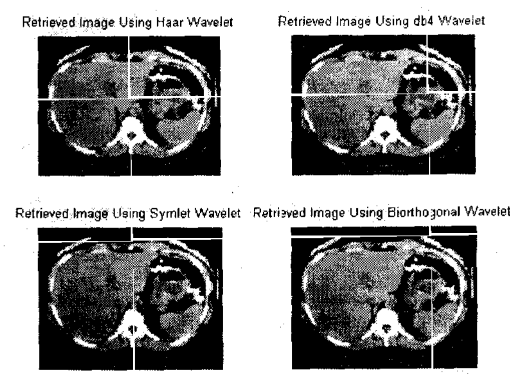
Scaled Image of DB4 Wavelet



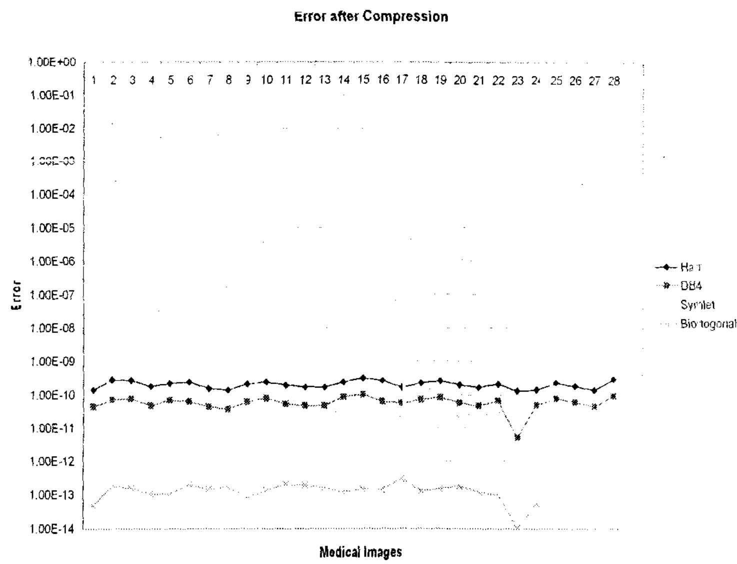
Scaled Image of Harr Wavelet



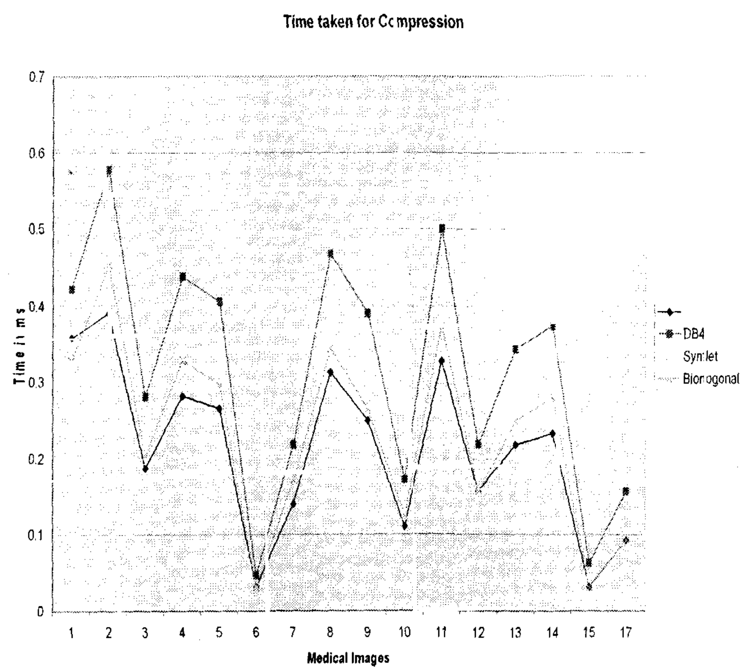
Retrieved Image of Harr, DB4, Symlet and Biorthogonal Wavelets



Error after Compression



Time taken for compression



3. Conclusion

Wavelet-based medical image compression prefers smooth functions of relatively short length. Our results show that different wavelet filters performed differently for different medical images. Experimental results indicate that the method of the biorthogonal wavelet has good performances with EZW in applying for image compression.

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