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Medical Image Compression Using EZW Coding

Chandrika V.[1*], Parvathi C.S.[2], and P. Bhaskar[3]

[123]Department of Instrumentation Technology, Gulbarga University P G. Centre, Yeragera - 584 133. Raichur, KARNATAKA, INDIA.

[*]E-mail: crgolds@rediffmail.com

Abstract: This paper proposes the implementation of an Enhanced Partial EZW algorithm that is based on the probability of significant coefficients within each bit plane on the lung X-ray image and thereby improves the performance. The main purpose of this paper is to analyse the impact and quality of wavelet filter for EZW and also to look into the effect of the level of wavelet decomposition towards compression efficiency. The wavelet filters used are Haar and Daubechies 9/7 (DB). The qualitative and quantitative results are presented.

Keywords: EZW wavelet transforms, JPEG 2000, Lossless Compression, Medical Image Compression Techniques, and Image Compression Standards.

1. INTRODUCTION

With the rapid expansion of computer technology, digital image processing places a great demand on efficient data storage and image content. Image compression is the application of Data compression on digital images. The compression is done in several ways i.e. lossy, lossless, near lossless & context based compression depending upon the requirement and the type of the medical image data. Since there is a limitation on channel bandwidth (BW) for the data transmission and the data transfer rate (bits per second(bps)), it is better to transmit the data in compressed form to avoid the problem of storage of huge data, speed of the data transfer, BW limitations, access speeds, costs, loss of the information and processing of the data . Broadly compression can be categorized in to two types as Lossy and Lossless methods. Lossless compression ensures complete data after reconstruction. In application of Lossy technique information is lost to some degree.

Discrete Wavelet Transform (DWT) provides a multiresolution image representation and has become one of the most important tools in image analysis and coding over the last two decades. Image compression algorithms based on DB 9/7 provide high coding efficiency for natural (smooth) images. A fundamental shift in the image compression approach came after the Discrete Wavelet Transform (DWT) became popular. Wavelet based on compression provides a very effective technique for medical images. Medical image requires storage of large quantity of digitized clinical data. Due to the high bandwidth and capacity of storage, medical image must be compressed before transmission. A popular method of image compression, namely, the embedded zero tree wavelet (EZW) which has less degree of loss. The EZW encoder is based on 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 details.

In medical image compression, diagnosis is effective only when compression techniques preserve all the relevant information needed without any appreciable loss of information. Lossy compression techniques are more efficient in terms of storage and transmission needs because of high compression ratio and the quality. 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 quality loss 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.

A popular method of image compression is the embedded zero tree wavelet. Increasingly, medical images are acquired and stored digitally. These images may be very large in size, number. Compression offers a means to reduce the cost of storage and increase the speed of transmission. Image compression minimizes the size in bytes of a graphics file without degrading the quality of the image. The resolution in file size allows more images to be stored in a given amount of disk or memory space. It also reduces the time required for images to be sent over the Internet or download from WebPages. Several compression algorithms were developed. J.M. Shapiro developed the embedded zero tree wavelet algorithm in which yields a fully embedded code and consistent compression [1]. With embedded coding, it is possible to recover the lossy version with distortion corresponding to the rate of the received image at the point of decoding process. EZW is a progressive image compression algorithm.

Any type of data transmission or storage without compression is impractical. Wavelet transforms have received significant attention in many fields, such as mathematics, digital signal and image processing, because of their ability to represent and analyze data. The basic idea is to choose the update filters according to some decision criterion which depends on the local characteristics of the input signal. These adaptive schemes yield lower entropies than schemes with fixed update filters, a property that is highly relevant in the context of compression. The discrete wavelet transform (DWT) was presented by many researchers on signal analysis and image compression have derived fruitful results due to its well time-frequency decomposition. Recently, a new wavelet construction called lifting scheme has been developed by Wim Sweldens and Ingrid Daubechies [2]. It has other applications, such as the possibility of defining a wavelet-like transform that maps integers to integers [3]. This method has gained increasing interest in scientific community; due to its reduced computational complexity by first factoring a classical wavelet filter into lifting steps. A number of adaptive wavelet transforms based on the lifting scheme have been proposed in the literature. Taubman [4] developed adaptive wavelet transforms to modify the prediction step by using the properties of the image. Since this predictor takes into account the fact that the discontinuities in images tend to occur along continuous curves, such adaptation of the predictor makes the transform non-linear [5, 6]. Exploiting local orientation information at edge boundaries, Calypoole et al. [7] proposed a prediction operator based on the local properties of the image. Ömer Nezih Gerek, A.Enisçetin described an adaptive poly phase structure based on the reduction of the variance[8]. N.V. Boulgouris et.al. first calculated the optimal predictors, by minimizing the prediction error variance, and then they apply these optimal predictor filters with adaptive update filters [9]. G. Piella's work is based on applying the update adaptive wavelet filter presented in to lossy image compression [10]. The approach taken in this paper differs from other adaptive schemes found in the literature. The choice of the update-lifting filter is triggered by a binary threshold criterion based on a generalized gradient that is chosen in such a way that it only smooths homogeneous regions [11]. In this paper Daubechies 9/7 based wavelet transforms are used for improved image compression. The usage of this filter has fetched better performance in terms of compression.

2. MEDICAL IMAGE COMPRESSION (MIC) TECHNIQUES

The medical imagery is to extract important features of the image which is provided by the computer to the other end user [12, 13]. The general technique behind MIC is to remove the redundant data from an image so as to find a more compact representation of the information. The MIC techniques are concerned with reduction of number of bits required to store and transmit the image data without any appreciable loss of useful information. In MIC, diagnosis and analysis are effective only when compression techniques preserve all the relevant and important image information needed [14, 15]. This is the case of lossless compression. Lossy compression, on the other hand, is more efficient in terms of storage and transmission needs but there is no guaranty to preserve the characteristics needed in medical diagnosis [16, 17].

3. IMAGE COMPRESSION STANDARDS

The joint photographic experts group (JPEG) is a very well known ISO/ITU-T standard created in the late 1980s and is based on discrete cosine transform (DCT) [18]. There are several modes defined in JPEG, including baseline, lossless, progressive and hierarchical. The baseline mode is the most popular one and supports lossy coding only.

The JPEG-LS is the latest ISO/ITU-T standard for lossless coding of still images. It also provides for 'near-lossless' compression [12, 18]. Near-Lossless compression is achieved by allowing a fixed maximum sample error. This algorithm is designed for low- complexity while providing high lossless CRs [19]. However, it does not provide support for scalability, error resilience or any such functionality.

The JPEG2000 (JPEG2K) is the next ISO/ITU-T standard for still image coding [20]. The Core coding system of JPEG2K specifying both lossy and lossless compression. The DWT is dyadic and can be performed with either the reversible Le Gall (5,3) taps filter, which provides for lossless coding, or the non-reversible Daubechies (9,7) taps Biorthogonal one, which provides for higher CR but does not do lossless.

LOCO-I (LOw COmplexity LOssless COmpression for Images) is the algorithm at the core of the new ISO/ITU standard for lossless and near-lossless compression of continuous-tone images [21]. It is conceived as a 'low complexity projection' of the universal context modeling paradigm, matching its modeling unit to a simple coding unit.

JPEG 2000 is the standard for wavelet compression issued by the JPEG Committee; it arose out of the need to harmonize the wavelet compression algorithm. JPEG 2000 uses a multilevel DWT with octave-scaled decompositions. JPEG 2000 is the new ISO standard for image compression commonly used to compress medical images.

4. METHODOLOGY

A simple block diagram of image compression system is shown in Figure1.The input image or preprocessed image is initially transformed using an appropriate transformation. Then it is quantized to reduce the bit size of the image. After that it is encoded and transmitted. Once the compressed image is transmitted it then undergoes decoding and dequantization. After this inverse transformation is applied to reconstruct the input image at the other end.

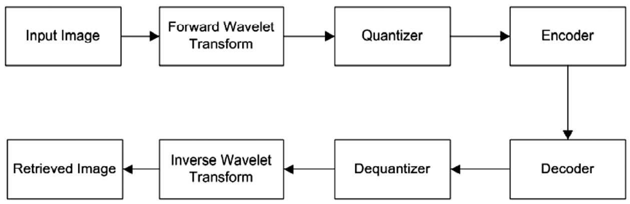


Figure 1: Block Diagram of Image Compression System

4.1. Embedded zero Tree Wavelet Coding

Fig. 2 shows the block diagram of implemented EZW coding system for image processing. The EZW algorithm was one of the first algorithms to show the full power of wavelet-based image compression. It was introduced in the paper of Shapiro [1]. An embedded coding is a process of encoding the transform magnitudes that allows for progressive transmission of the compressed image. Zero trees allow for a concise encoding of the positions of significant values that result during the embedded coding process.

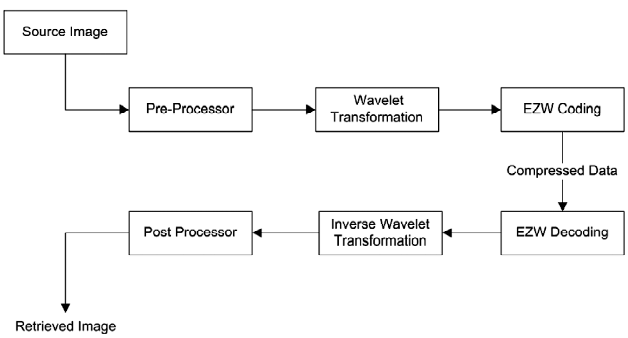


Figure 2: EZW Coding System

One of the most important characteristics of DWT is multiresolution decomposition. An image decomposed by wavelet transform can be reconstructed with desired resolution. When first level 2D DWT is applied to an image, it forms four transform coefficients. The first letter corresponds to applying either low pass or high pass filter to rows and the second letter refers to filter applied to columns. The elimination of high pass components by 2D wavelet transform technique reduces the computation time by reducing the number of arithmetic operations and memory accesses and communication energy by reducing the number of transmitted bits. With the increase in the levels of decomposition, the compression can be made efficient correspondingly, the inverse DWT are performed in the decompressor block. A Quantizer simply reduces the number of bits needed to store the transformed coefficients by reducing the precision of those values. Since this is a many to one mapping, it is a lossy process and is the main source of compression in an encoder. In uniform quantization, Quantization is performed on each individual coefficient. EZW is a progressive image compression algorithm i.e., at any moment, the quality of the displayed image is the best available for the number of bits received up to that moment.

Compared with JPEG - the current standard for still image compression, the EZW and the SPIHT are more efficient and reduce the blocking artifact. The block diagram of encoder part of the proposed EZW algorithm is given in Fig. 3.

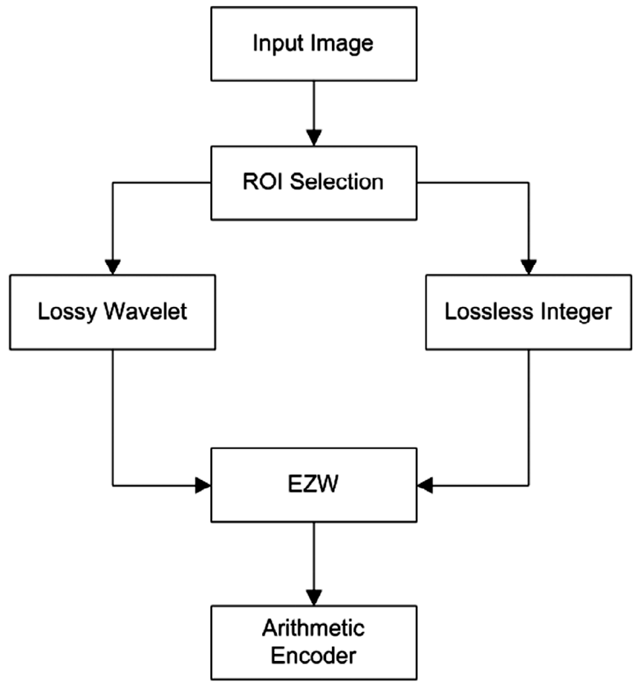


Figure 3: EZW Encoder

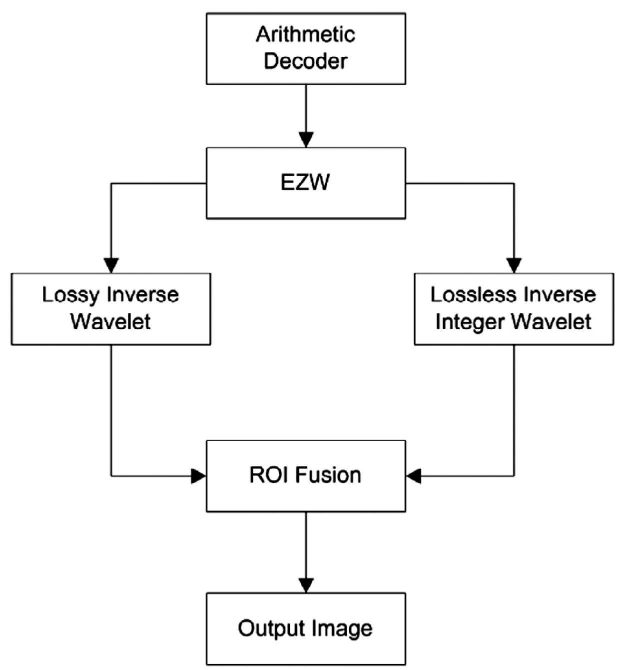


Figure 4: EZW Decoder

EZW encoder is based on 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, leads to 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 components of the image obtained from the transformation module and pass the data to the decoder unit to retrieve the image back. The block diagram of EZW decoder is given in Fig. 4.

4.2. Choice on Wavelets

Important properties of wavelet functions in image compression applications are compact support. In this paper, Haar wavelet Daubechies 9/7 wavelet are considered. A Haar wavelet is the simplest type of wavelet. One distinctive feature that the Haar transform enjoys is that it lends itself easily to simple hand calculations. For the Daubechies 9/7 wavelet transforms, the scaling functions and wavelets have slightly Longer supports, i.e., they produce averages and differences using just a few more values from the signal. Figure 5 shows the flowchart of the EZW algorithm.

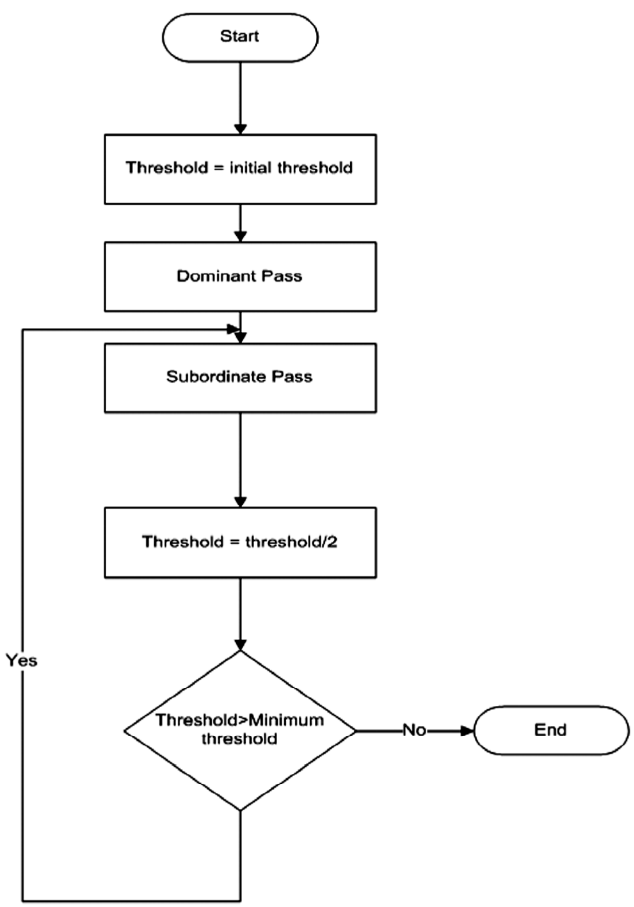
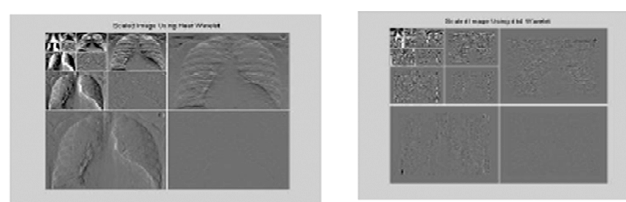


Figure 5: Flowchart EZW Algorithms

5. RESULTS

In this article the EZW algorithm which has been applied on the lung X-ray images, which has efficiently compressed the images. Fig. 6 shows the original image and Figure 7 shows the Haar and DB transformed wavelet images.

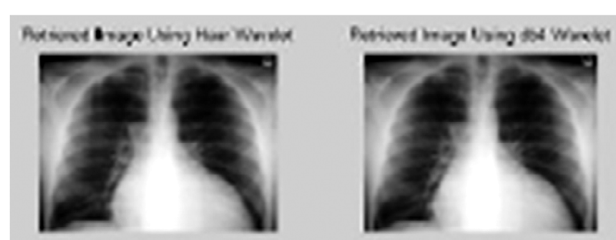
Figure 6: Original Image



(a) (b)

Figure 7: Wavelet Transfromed Images Using Haar and DB

In Fig.7(a) we can see that at the mid band frequency compression is not efficient and in 7(b) we can observe that less details in the mid band frequency components i.e it takes less bits after compression. Band width is also appriciable and the transfer rate is high i.e. time taken to transfer the image (bits/second) is less. Figure 8 Shows the comparision of de-compression of X-Ray images under EZW Coding Technique Using Haar and DB wavelet.



(a) (b)

Figure 8: Decompressed Images of Haar and DB

6. CONCLUSION

We used the DB 9/7 wavelet compression coupled with the EZW coding and found that this algorithm gives better results than the other compression techniques.EZW has many advantages, such as good image quality, high PSNR (Peak Signal to Noise Ratio) and good progressive image transmission. Hence, it also has wider application in the compression of images.

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