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A PERFORMANCE AND ANALYSIS OF EZW ENCODER FOR IMAGE COMPRESSION

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Abstract
Current image coding systems use wavelet transform, which decompose the image into different levels, where the coefficients in each sub band are uncorrelated from coefficients of other sub bands. As a result the coefficients in each sub band can be quantized independently of coefficients in other sub bands with no significant loss in performance. But the coefficient in each sub band requires different amount of bit resources to obtain best coding performance. This results in different quantizer with each sub band having its own bit rate. This gives an issue to bit allocation under image processing. Hence sub band coding can be used for achieving high bit rate. Embedded zerotree wavelet (EZW) encoder is designed to use wavelet transform. EZW coding exploits the multi-resolution properties of the wavelet transform to give a computationally simple algorithm with better performance. A performance analysis of image compression system for various formats of image is considered with EZW based on different wavelets.
The main purpose of this paper is to investigate the impact of different wavelets on image compression using EZW. The effect of the level of wavelet decomposition on compression efficiency is analyzed. The Haar, Dauhechies 4 and bio-orthogonal wavelets are used. The compression simulations are done on few modalities of images. The qualitative and quantitative results of these simulations are presented.

Keywords: *EZW, performance, Image Compression.*

1 Introduction

Digital imagery has an enormous impact on industrial, scientific and computer applications. It is no surprise that image coding has been a subject of great commercial interest in today's world. Uncompressed digital images require considerable storage capacity and transmission bandwidth. Efficient image compression solutions are becoming more critical with the recent growth of data intensive, multimedia-based web applications. A popular method of image compression, namely, the embedded zero tree wavelet. 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 detail, a property similar to JPEG encoded images [3].

Coding an image using the EZW scheme, together with some optimizations results leads to 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, but of course with less spectacular results [1]-[2].

An embedded code represents a sequence of binary decisions that distinguish an image from the null or all gray, image. Since embedded at the beginning of the bit stream, effectively, the bits are ordered. Using an embedded code, an encoder can terminate the encoding at any point there by

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allowing a target rate or distortion metric to be met exactly. Embedded coding is similar in spirit to binary finite precision representations of real numbers. All the real numbers can be represented by a string of binary digits for each digit added to right [2].

The embedded zero-tree wavelet coding for image processing proposed by Shapiro [1] uses embedded coding for image compression. The embedded zero-tree wavelet coding uses the wavelet coefficients for encoding. Wavelet transmission decomposes an image into sub-bands as detail and approximate coefficients. The JPEG 2000 coding system achieves image compression using different wavelet transform [3]-[4].

For progressive transmission, image browsing, multimedia applications, and compatible transcoding, the problem of obtaining the best image quality for targeted bit rate is a difficult task. Additionally, JPEG image coder requires an extensive training for both quantization (both scalar and vector) and generation of entropy codes for encoding. As images are of huge data set and encoding for a lower bit rate results in loss of data, which in turn results in degradation of image quality. To overcome these problems, an enhancement to the existing encoding system is needed. The objective of the proposed work is to realize embedded zerotree wavelet (EZW) encoder for different wavelets namely, Haar, DB4, and Bio-orthognal, and to obtain performance analysis of EZW encoder for image compression [5]-[6].

2 Embedded zero tree wavelet coding

Embedded Zero-tree Wavelet 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, a property similar to JPEG encoded images.

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.

a) The Algorithm

The EZW output stream starts with information to synchronize the decoder. The minimum information required by the decoder for its functionality is the number of wavelet transform levels used and the initial threshold. Basically, a constant level (3) of wavelet transform is used for transformation. The first step in the EZW coding algorithm is to determine the initial threshold. The initial threshold t_0 is given as $t_0=2^{[\log_2(MAX(|\gamma(x,y)|))]}$. where $MAX(|\gamma(x,y)|)$ means the maximum coefficient value in the image and $\gamma(x,y)$ denotes the coefficient. Then taking the obtained threshold as the initial value the scaled sub-band samples are subjected to dominant pass and subordinate pass. Under each pass, the threshold is decreased by half the value. This comparison is carried out until the threshold reaches to the minimum threshold.

The EZW encoder is based on two important observations: (i) Natural images in general have a low pass spectrum. When an image is wavelet transformed, the energy in the subbands decreases as the scale decreases (low scale means high resolution), so the wavelet coefficients, on average, are smaller in the higher subbands than in the lower subbands. This shows that progressive encoding is a very natural choice for compressing wavelet-transformed images, since the higher subbands only add detail parameter. (ii) Large wavelet coefficients are more important than small wavelet coefficients.

These two observations are used for encoding the wavelet coefficients in decreasing order, in several passes. For every pass, a threshold is chosen against which all the wavelet coefficients are measured. If a wavelet coefficient is larger than the threshold, it is encoded and removed from the image. If it is smaller, it is left for the next pass. When all the wavelet coefficients have been visited the threshold is lowered and the image is scanned again to add more detail to the already encoded image. This process is repeated until all the wavelet coefficients have been encoded completely.

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b) Dominant Pass

The image is scanned and a symbol is returned for every coefficient. If the coefficient is larger than the threshold, a **P** (positive) is coded. If the coefficient is smaller than negative of threshold, an **N** (negative) is coded. If the coefficient is the root of a zero tree, then a **T** (zero tree) is coded. Finally, if the coefficient is smaller than the threshold but it is not the root of a zero tree, then a **Z** (isolated zero) is coded. This happens when the coefficient is larger than the threshold in the sub tree. All the coefficients that are in positive value, larger than the current threshold, are extracted and placed without their sign on the subordinate list and their positions in the image are filled with zeroes.

c) Subordinate Pass

The dominant pass is always followed by a subordinate pass where the coded data get binary coded (in 1 or 0) i.e which to be transmitted. A wavelet transform represents a signal from the time domain in to the joint time-scale domain. i.e. the wavelet coefficients are two-dimensional. To compress the transformed signal, not only the coefficient values but also their position in time has to be coded. When the signal is an image, then the position in time is better expressed as the position in space. After wavelet transforming an image it can be represented using trees because of the sub sampling that is performed in the transform. A coefficient in a lower subband can be thought of as having four descendants in the next higher subband as shown figure below. The four descendants each also have four descendants in the next higher subband, which gives a quad-tree, with every root having four leafs. A zerotree is defined as a quad-tree of which all nodes are equal to or smaller than the root and the root is smaller than the threshold against which the wavelet coefficients are currently being measured. The tree is coded with a single symbol and reconstructed by the decoder as a quad-tree filled with zeroes. The EZW encoder codes the zero-tree based on the observation that wavelet coefficients decrease with scale. In a zerotree all the coefficients in a quad tree is be smaller than the threshold if the root is smaller than this threshold. Under this case the whole tree can be coded with a single zerotree (T) symbol.

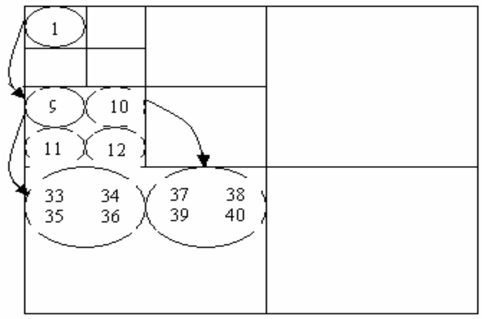

Figure 2. The inter relationship of multiple levels in wavelet scaled image

EZW encoding uses a predefined scan order to encode the position of the wavelet coefficients. Through the use of zerotree many positions are encoded implicitly. Several scan orders are possible, as long as the lower subbands are completely scanned before going on to the higher subbands. The relations between wavelet coefficients in different subbands, and there scan path is show in fig 2 and fig 3. In the above shown example an H indicates the coefficient, which is higher than the threshold, and an L indicate a coefficient, which is below the threshold. The zerotree symbol (T) replaces the four L's in the lower left part and the L in the upper left part

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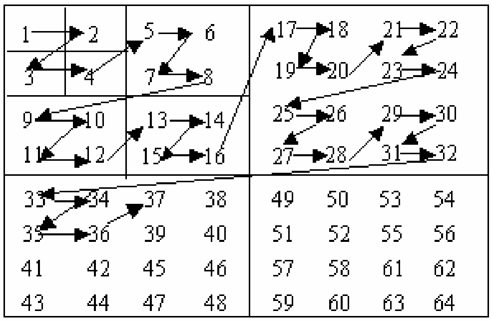

Figure 3. Scanned order for embedded coding

3 Approach

The design unit implements the embedded zero-tree wavelet coding system for data compression. The coding system reads the multiresolution component of the image obtain from the transformation module and pass the data to the decoder unit to retrieve the image back.

Before the processing of image data the image 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 (source) image into rectangular non overlapping blocks (tiles), 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 (i.e., the whole image is regarded as one tile). 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 shown in fig 2 for the 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. The embedded zero tree wavelet (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 $T_0 = 2\text{^}(\log_2 x_{max})$. 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 there 4 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, zero tree and isolated zero tree. 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 level been arranged at the top. fig 3 shows the reconstruction of the obtained decomposed component.

4 Results of Scale 4

Results of Harr, DB4, Bio-Orthogonal & Compression of Error Time Taken for Compression.

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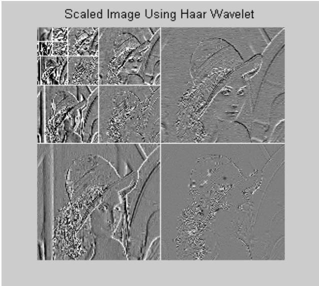

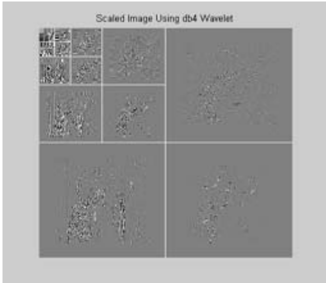

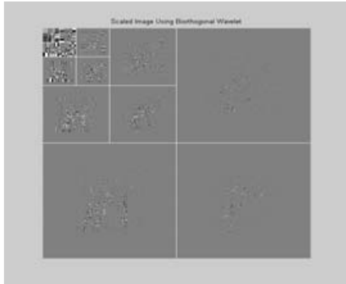

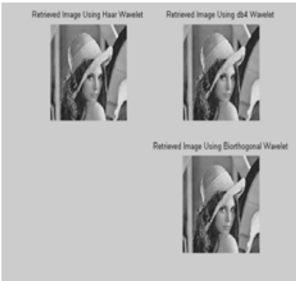

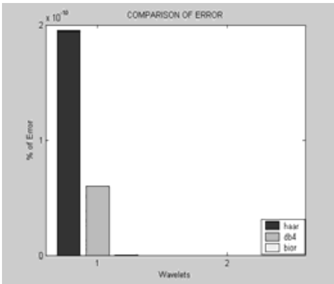

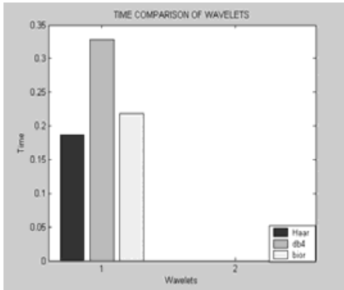

5 Conclusion

Using EZW encoder, different wavelet like Haar DB4 and Bio-orthogonal to compress an image into a bit stream with increasing accuracy. It is observed that, when more bits are added to the stream, the decoded image will contain more detail. Every digit we add to increases the accuracy, but we can stop at any accuracy we like. Progressive encoding is also known as embedded encoding, which explains the E in EZW.

It has observed with experimental results the Bio-Orthogonal wavelet transform is computationally more efficient than DB4 and Haar wavelets.

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