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A Survey on Embedded Zero Tree Wavelet

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***Abstract*— An image compression method shows dynamic part in multimedia and satellite applications. Wavelet transforms need conventional significant care newly due to their suitability for a number of signal and image compression applications and they have established their viability for the same. This is mainly due to the lapped nature of this transform and the computational simplicity, which comes in the form of filter bank implementations. In this paper, we discuss zero tree, embedded Zero Tree and Zero Tree Wavelet Coders such as Embedded Zero tree Wavelet (EZW) coder, EZW algorithm.**

***Index Terms*—Zero Tree, Embedded Zero Tree Wavelet (EZW), EZW Coder, EZW algorithm.**

INTRODUCTION

The size of digitized images, used in several applications is actual high that significantly slow down the transmission and creates storage prohibitively high. Therefore, the evidence contained in the images essential is compressed by extracting only the visible elements [1]. Compression can be attained by transmuting the data, projecting it on a basis of functions and then encoding these transformed values. Wavelets have expected considerable attention for image compression benefits because it can hierarchically decay an input image into a sequence of successively low resolution guesstimate images and their associated detail images. EZW image coding is attained by allocating bandwidth rendering to the comparative importance of information in the guesstimate and detail images and then applying quantization to the transformed data values [2].

I. EZW ENCODER AND THE ZERO TREE

An EZW encoder is an encoder specially designed to use with wavelet transforms, which explains why it has the word wavelet in its name. The EZW encoder was originally designed to operate on images (2D-signals) but it can also be used on other dimensional signals. 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 [2]. It is also similar to the representation of a number like π. Every digit we add increases the accuracy of the number, but we can stop at any accuracy we like. Progressive encoding is also known as embedded encoding, which explains the E in EZW. 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 stands only possible if there is material loss somewhere so that the compressor is loss. However, lossless compression is also possible with an EZW encoder, but of course with fewer spectacular results [3].

The EZW encoder is founded on two important observations:

1. Usual images in common has low pass spectrum. When an image is wavelet changed the energy in this subbands decreases as the scale decreases (low scale means high resolution), so this wavelet coefficients will, on usual, be smaller in the higher subbands than in the lower subbands. This shows that the progressive encrypting is a very usual choice for compressing wavelet transformed images, since the higher subbands only add detail [3].
2. Large wavelet coefficients are more significant than smaller wavelet coefficients.

These two explanations are exploited by this EZW encoding scheme by coding the coefficients in the reducing order, in quite a lot of permits. For every permit a threshold is selected against which all the coefficients are measured. If a wavelet coefficient is larger than the threshold it is encoded and detached from the image, if it is lesser it is left for the next

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permit. When entire the wavelet coefficients have been go to the threshold is lowered and the image is scanned once more to add more detail to the already encoded image. This procedure is repetitive until all the wavelet coefficients have been encoded completely or additional criterion has been fulfilled (highest bit rate for instance)[2].

The trick is now to use the dependence between the wavelet coefficients through different scales to efficiently encode vast parts of the image which are under the current threshold. It is here where the zero tree arrives.

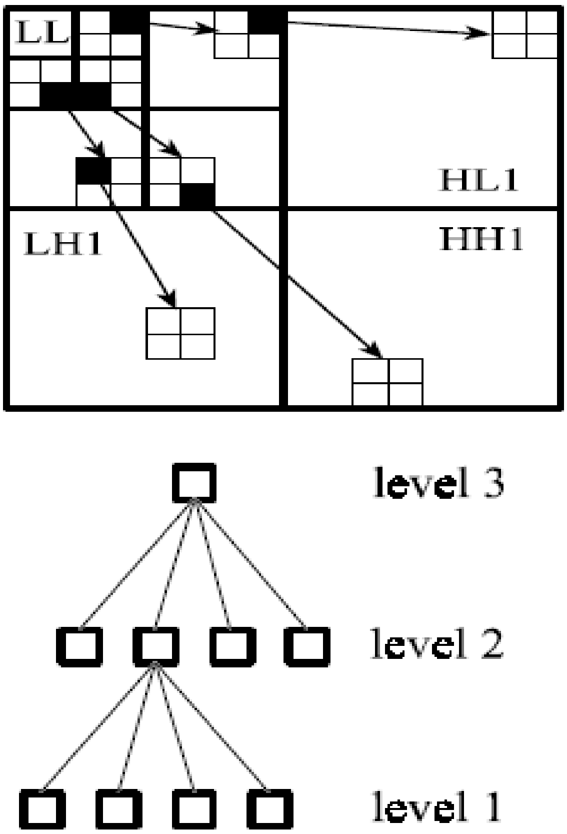

Fig. 1 Relations between wavelet coefficients in unrelated sub bands as quad-trees.

A wavelet transform converts a signal from the time domain to the joint time-scale domain. This means that the wavelet coefficients are two-dimensional [4]. If we want to compress the transformed signal it has to code not only the coefficient values, but also their location in time. When the signal is an image then the location in time is better expressed as the location in space. Afterward` wavelet transmuting an image we can signify it by trees because of the sub-sampling that is completed in the transform. A coefficient in a lesser sub band can be supposed of as having four descendants in the following higher sub band (Fig. 1). The four descendants all also have four descendants in the following higher sub band and it shows a quad-tree emerges: every root has four leafs.

A zero tree is a quad-tree of which entirely nodes are equal to or lesser than the root. The tree is coded with a single representation and reconstructed by the decoder as a quad-tree occupied with zeroes. To clutter this definition we have to add that the root has to be smaller than the threshold against which the wavelet coefficients are currently being measured.

The EZW encoder exploits the zero trees based on the observation that wavelet coefficients decrease with scale. It assumes that there will be a very high probability that all the coefficients in a quad tree will be smaller than a certain threshold if the root is smaller than this threshold [4]. If this is the event then the whole tree can be coded with a single zero tree symbol. Now if the image is scanned in a predefined command, going from high scale to low, implicitly many locations are coded through the usage of zero tree symbols. Of course the zero tree rules will be dishonoured often, but as it turns out in exercise, the probability is still very high in common. The value to pay is the adding of the zero tree symbols to our code alphabet.

Zero Tree Working Procedure

An easiest method is to just transmit the values of the coefficients in decreasing order, but this is not actual effectual. These approaches a lot of bits are spend on the coefficient values and operator do not usage the fact that user know that the coefficients are in reducing order. A good approach is to use a threshold and only the signal to the decoder if the values are greater or lesser than the threshold. If it also conveys the threshold to the decoder, it can rebuild already quite a more. To arrive at a perfect rebuilding we recap the process after lowering the threshold, until the threshold has become smaller than the smallest coefficient we required to convey. It can make this process very efficient by deducting the threshold from the values that were larger than the threshold. This output in a bit stream with growing accuracy and which can be perfectly rebuilt by the decoder. If we use a prearranged order of thresholds then we do not have to convey them to the decoder and thus save us selected bandwidth. If the prearranged sequence is a sequence of powers of two it is called bit plane coding meanwhile the thresholds in this case correspond to the bits in the binary demonstration of the

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coefficients. EZW encoding as defined in uses this type of coefficient assessment encoding [5].

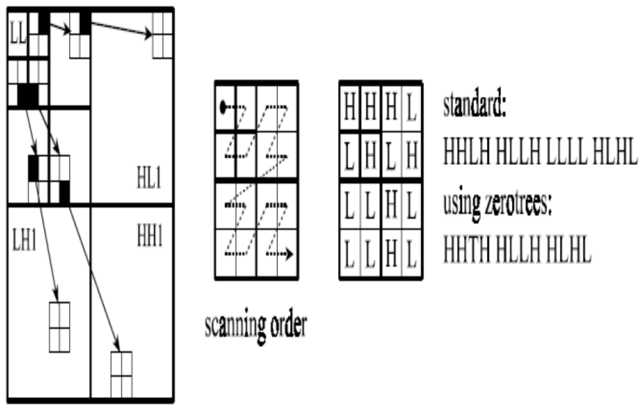

Fig. 2 The relationships between wavelet coefficients in dissimilar sub bands (left), how to scan them (upper right) and the result of by zero tree (lower right) symbols (T) in the coding process. An H means that the coefficient is greater than the threshold and an L means that it is below the threshold.

One essential thing is however still missing: the transmission of the coefficient places. Indeed, without this information the decoder will not be able to rebuild the encoded signal (although it can perfectly reconstruct the transmitted bit stream). It is in the encoding of the locations where the efficient encoders are separated from the inefficient ones. As mentioned before, EZW encoding uses a predefined scan order to encode the location of the wavelet coefficients (see figure 2). Through the usage of zero trees many positions are encoded implicitly. A number of scan orders are possible as long as the lower sub bands are totally scanned before successful on to the higher sub bands. In a raster scan order is used, while in some other scan orders are mentioned. The scan order appears to be of some influence of the finishing compression result.

ZERO TREE STRUCTURE

Usually, most of the energy in an image is concentrated in the low-frequency region. When an image is subjected to n-level decomposition using DWT, the nth level would parallel to the lowermost frequency sub-band and would correspond to the coarsest resolution. Thus, when one changes from higher levels to lesser levels of sub-band decomposition, there would be a reduction in the energy content of the sub-band. Consequently most of them, based on a threshold value, can be quantized to zero without affecting the perceived excellence of the image. All wavelet based image compression techniques takings benefit of this phenomenon. Moreover, there are spatial self-similarities through sub-bands. To increase the compression of significance maps of wavelet coefficients, a new data structure called a zero tree is defined.

A wavelet coefficient x is said to be insignificant with respect to a given threshold T if $|x| < T$. The zero tree is based on the hypothesis that if a wavelet coefficient at a coarse scale is insignificant with respect to a given threshold T, then all wavelet coefficients of the similar orientation in the similar spatial position at better scales are likely to be insignificant with respect to T. Empirical evidence proposes that this hypothesis is often true. More specifically, in a hierarchical sub-band system with the exception of the highest frequency sub-bands, every coefficient at a given scale can be related to a set of coefficients at the next finer scale of similar orientation [2].

The coefficient of the coarse scale is called the parent, and all coefficients equivalent to the same spatial location at the next finer scale of similar orientation are called children. Because of the parent child dependencies across sub bands.

EZW CODING

The EZW coding algorithm provides outstanding compression ratio than the previous thresholding techniques by manipulating the spatial self- similarities of the zero tree structure [2]. Since the embedded code covers all lower rate codes "embedded" at the beginning of the bit stream effectively, the bits are "ordered in importance". Using an embedded code, an encoder can terminate the encrypting at any point thereby permitting a target rate or distortion metric to be met exactly [3].

EZW coding consists of two passes, viz., (i) dominant pass and (ii) refinement pass. In dominant pass, at all particular threshold, all the coefficients are scanned to test the zero tree hypotheses in a special order, namely raster scan or Morton scan. If the hypothesis is true for the coefficient, it will be encoded as zero tree roots [11]. All its descendants do not need to be encoded i.e., they will be reconstructed as zero at this threshold level. If the coefficient itself is insignificant but one of its descendants is significant, it is encoded as isolated zero. If the coefficient is significant then it is encoded as positive or negative depends on its sign.

This encoding of the zero trees produces significant compression because gray level images resulting from natural sources typically result in DWTs with many zero tree root symbols. In the refinement pass, the next most significant bit of all the significant coefficients for the given threshold is being sent. Then, the threshold is scaled down by two and

International Journal of Computer Science
Oddity...Probe...Reviste...
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continues with dominant pass until the coded bit meets required target bit rate [6].

THE EZW ALGORITHMS

The EZW output stream will have to start with some information to synchronize the decoder. The minimum information required by the decoder is the number of wavelet transform levels used and the initial threshold, if we assume that always the same wavelet transform will be used. Additionally we can send the image dimensions and the image mean. Sending the image mean is valuable if we remove it from the image earlier coding. After imperfect reconstruction the decoder can then replace the imperfect mean by the original mean. This can increases the PSNR significantly.

The Embedded Zero tree Wavelet (EZW) algorithm has demonstrated to be an extremely efficient and flexible compression algorithm for low bit rate image coding. The embedding algorithm attempts to order the bits in the bit stream in numerical importance and thus, a given code covers all lower rate encodings of the same algorithm. Thus, precise bit rate control is achievable and a target rate or distortion metric can be met accurately. Additional, the method is fully image adaptive, doesn't even essential to see the dynamic variety of the numbers being compressed. Because of the embedding and adaptively features of EZW, sensible pre-processing at the encoder and the corresponding opposite post-processing at the decoder can be used to change the numerical optimization used in EZW to other criteria such as a subjective one or one which favours critical regions as demonstrated by an application called "Smart Compression".

Prior to the development of EZW, compression algorithms were generally trained and optimized for a particular class of images and for certain compression ratios. One of the original motivations for EZW was to develop an algorithm that was as general as possible with respect to image class or target bit rate. EZW achieves these goals via its embedding feature and its adaptively feature. The embedding feature states that for a given code for an image, all lower rate codes are embedded at the beginning of the bit stream [12]. In other words, the information is ordered in numerical importance in the sense that the most significant bits of the largest wavelet coefficients are represented before bits of lesser significance of smaller coefficients are represented [8]. This information is then sequentially encoded so that at any truncation by either the encoder or decoder contains the best EZW representation at the corresponding lower bit rate.

From an encoder point of view, higher compression ratios are obtained simply by terminating the sequential process early. From the decoder's point of view, progressive transmission is achievable and the decoder can stop as soon as the quality is sufficient for the specific application. This magnitude- based prioritization also makes intuitive sense.

Most compression algorithms, even other wavelet compression approaches, implicitly define lower frequency coefficients as more important than higher frequency coefficients. In contrast, EZW treats larger coefficients as more important than smaller coefficients regard- less of the frequency range of the coefficient [9]. Under most circumstances large coefficients are also low frequency, however, for high contrast details, some high frequency coefficients are also large, and thus EZW treats this detail information as extremely important by representing it early in the bit stream. The adaptively feature circumvents the need for training the algorithm to a class of images.

EZW is fully adaptive and it appears to work well with any image type [11]. Initially it would seem that these two features would place constraints on the compression algorithm so that other techniques that didn't have these features and were specifically optimized for particular image types would perform better. Surprisingly, using numerical objective metrics, the EZW algorithm has been consistently more efficient than other approaches, even those that have been trained on similar images [3]-[6]. The penalty for using EZW is that although it is order of magnitudes faster than fractal compression [2], it requires approximately 2-3 times as much computation as 8 x 8 blocks DCT based techniques such as JPEG. However, the compression performance obtained with EZW when measured numerically is far superior to that of JPEG especially at high compression ratios [6].

ADVANTAGES OF ZERO TREE CODING

In the algorithm described above, zero tree coding is used to code significance maps at each threshold. Using scalar quantization followed by entropy coding, in order to achieve very low bit rates, i.e., less than 1 bit/pel, the probability of the most likely symbol after quantization - the zero symbols - must be extremely high. Typically, a large fraction of the bit budget must be spent on encoding the significance map, or the binary decision as to whether a sample, in this case a coefficient of a 2-D discrete wavelet transform, has a zero or non-zero quantized value. It follows that a significant improvement in encoding the significance map translates into a significant [10].

In the algorithm described in the previous section, a ternary significance map - where the sign is included - is actually encoded at each dominant pass. Even though the image has

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been transformed using a decor relating transform, the occurrences of insignificant coefficients are not independent events. Zero trees reduce the cost of encoding the significance map using self-similarity.

CONCLUSION

This paper describes about the Zero tree, The EZW structure, embedded Zero Tree and Zero Tree Wavelet Coders such as Embedded Zero tree Wavelet (EZW) coder, EZW algorithm. Zero tree coding is used to code significance maps at each threshold. Using scalar quantization followed by entropy coding, in order to achieve very low bit rates. The EZW encoder is based on progressive encoding to compress an image into a bit stream with increasing accuracy.

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