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Comparative analysis of Embedded Zero tree and Fractal Image Compression Techniques

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Abstract- **Compressing an image is significantly different than compressing raw binary data. For this different compression algorithm are used to compress images. Fractal image compression (FIC) has been widely used to compress the image. Apart from FIC, their also exist another algorithm well known as Discrete Wavelet Transform (DWT). Wavelet transform are very powerful compared to other transform because its ability to describe any type of signals both in time and frequency domain simultaneously. The proposed schemes investigate the performance evaluation of FIC and wavelet based compression algorithm- Embedded Zero Tree (EZW) based image compression. The numerical analysis of such algorithms is carried out by measuring Peak Signal to Noise Ratio (PSNR), Compression Ratio (CR).**

Keyword- **Image Compression, Discrete Wavelet Transform, fractal image compression (FIC), embedded Zero Tree, filters.**

I. INTRODUCTION TO IMAGE COMPRESSION

Compression of digital images plays an important role in the image storage and transmission. The advanced in the technology have made use of digital image very common in everyday life. We have seen that cost of storage and transmission of image is much more as compared to text. Therefore there need to compress the image before transmission. The principle behind image compression is that the neighboring pixels are correlated and therefore contain redundant information. The foremost task then is to find less correlated representation of the image and to reduce redundancy of the image data in order to be able to store or transmit data in an efficient form. [1]

There are varieties of image compression algorithm available. But broadly image compression algorithms are categorized into two i.e. lossy and lossless image compression. The Lossless compression is preferred for archival purposes and often medical imaging, technical drawings, etc. This is because lossy compression methods, especially when used at low bit rates, introduce compression artifacts. Lossy methods are especially suitable for natural images such as photos in applications where minor (sometimes imperceptible) loss of fidelity is acceptable to achieve a substantial reduction in bit rate. In general, lossy techniques provide for greater compression ratios than lossless techniques i.e. Lossless compression gives good quality of compressed images, but yields only less compression whereas the lossy compression techniques [2] lead to loss of data with higher compression ratio. The approaches for lossy compression include lossy predictive coding and transform coding. Transform coding, which applies a Fourier-related transform such as DCT and Wavelet Transform such as DWT are the most commonly used approach. [3] Over the past few years, range of wavelet based image compression algorithm has been developed and implemented. The coders provide a better quality in the images. There are several algorithms for wavelet based compression such as Embedded Zerotree Wavelet (EZW), Set Partitioning in Hierarchical Trees (SPHIT), Embedded Block Truncation Coding (EBOTC) etc. [4]

In this paper we will analysis performance of transform coding techniques of lossy image compression i.e. fractal image compression (FIC) and well known wavelet based image coding technique i.e. DWT-EZW. The performance is evaluated based on different performance measures such as Compression Ratio (CR), Peak to Noise Ratio (PSNR) and Mean Square Error (MSE).

The paper is organized as follows: Section II explains embedded zero tree (EZW); Section III explains fractal image compression Algorithm; Section IV include Experiment Results and Discussion and Section V gives the conclusion.

Wavelet transform is the latest method of compression where its ability to describe any type of signals both in time and frequency domain. JPEG2000 which is the standards of international image coding is adopted the method of wavelet transform coding. An M*N image is decomposed using wavelet transform. The image is decomposed into four sub-bands after passing a high- pass filter and low- pass filter. The four sub-bands are LL, HL, LH and HH respectively. The one obtained by low pass filtering rows and columns is referred as LL sub band contains horizontal details of the image. The one obtained by low pass filtering the rows and high pass filtering the columns is referred to as the LH sub band contains vertical details of the image and HH sub band contains the diagonal details of the image. The process is called the first level of wavelet decomposition. The low frequency sub-band can be continually decomposed into four sub-bands. [3]

The image of low frequency sub-band contains major information. The values of high frequency sub-band approximate zero, the more high frequency the more obvious this situation. For image, the part of the low frequency is primary part which can represent the image information. So researchers take full advantage of the characteristic after wavelet transform and employ proper method to process the image coefficients for achieving effective compression.

II. EMBEDDED ZERO-TREE WAVELET (EZW) ALGORITHM

Embedded zero-tree coding of wavelet coefficients (EZW) was introduced by Shapiro [5]. Shapiro design the algorithm based on empirical true hypothesis that if a wavelet coefficient at a coarse scale is insignificant with respect to a threshold T, then all wavelet coefficients of the same orientation in the same spatial location at finer scale are likely to be insignificant with respect To T. In an attempt to exploit the dependencies embodied in the replicated regions of small coefficients, all the coefficients corresponding to the same spatial location are organized in trees. These trees induce a parent–child relationship among the coefficients of subbands having the same spatial orientation. These parent–child dependencies are generally credited for the excellent performance of zero-tree coders. [6] The coefficient at the coarse scale is called the parent, and all coefficients corresponding to the same spatial location at the next finer scale of similar orientation are called children.

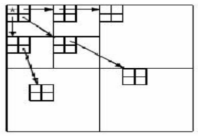

Fig2: Parent-child dependencies

The EZW coding algorithm can now be summarized as follows.

Two lists are used by the encoder (and also by the decoder, which works in lockstep) in the scanning process. The dominant list contains the coordinates of the coefficients that have not been found to be significant. The subordinate list contains the magnitudes of the coefficients that have been found to be significant. Each list is scanned once per iteration. Iteration consists of a dominant pass followed by a subordinate pass. Following are steps of EZW coding algorithm:

1. Initialization: Place all wavelet coefficients on the dominant list. Set the initial threshold to T0= 2log2xmax
2. Dominant Pass: Scan the coefficients on the dominant list using the current threshold Ti and sub band ordering. Assign each coefficient one of four symbols:

- positive significant (ps)—meaning that the coefficient is significant relative to the current threshold Ti and positive,
- negative significant (ns)—meaning that the coefficient is significant relative to the current threshold Ti and negative,
- isolated zero (iz)—meaning the coefficient is insignificant relative to the threshold Ti and one or more of its descendants are significant,
- zero-tree root (ztr)—meaning the current coefficient and all of its descendants are insignificant relative to the current threshold Ti .

Any coefficient that is the descendant of a coefficient that has already been coded as a zero-tree root is not coded, since the decoder can deduce that it has a zero value. Coefficients found to be significant are moved to the subordinate list and their values in the original wavelet map are set to zero. The resulting symbol sequence is entropy coded [7].

3. Subordinate Pass: Output a 1 or a 0 for all coefficients on the subordinate list depending on whether the coefficient is in the upper or lower half of the quantization interval.
4. Loop: Reduce the current threshold by two, T =T i / 2.

Repeat the Steps 2) through 4) until the target fidelity or bit rate is achieved. [8]

III. FRACTAL IMAGE COMPRESSION (FIC)

Fractal is one effective method to describe natural modality in the process of transformation and iteration. In 1973, Benoit Mandelbrot firstly brought forward the idea of fractal geometry, Infinity self-similarity is the soul of fractal. In 1989, Amaud Jacquin and Michal Barnsley realized a first automatic fractal encoding system. [9]

Fractal image compression is also called as fractal image encoding because compressed images are represented by contractive transforms. These transforms are composed of collection of a number of affine mappings on the entire image, known as Iterated Function System (IFS).

In FIC the image is decomposed twice, into overlapping domain blocks with size D*D to make a domain pool. Then we decompose the image again into non-overlapping range blocks with size R*R, and usually D=2*R. This type of decomposition is closely related to quad –tree (parent child relationship) where domain block forms parent and small four range block forms children. The whole process of fractal image encoding is shown in Fig. 1. [11].

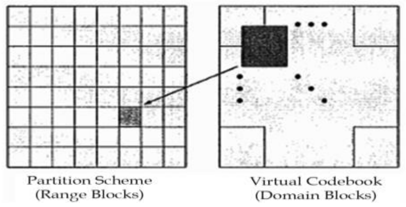

Fig:2 partition scheme of range block and mapping to domain block.

After decomposition, for each range block we search for best matched domain block in the domain pool with a contractive affine transformation Wi, which can be defined by the following function[12]

$$W_i\begin{pmatrix} x \\ y \\ p_{xy} \end{pmatrix} = \begin{pmatrix} a_i & b_i & 0 \\ c_i & d_i & 0 \\ 0 & 0 & s_i \end{pmatrix}\begin{pmatrix} x \\ y \\ p_{xy} \end{pmatrix} + \begin{pmatrix} u_i \\ v_i \\ o_i \end{pmatrix}$$

Where x and y are the spatial coordinates of the image block and pxy is the pixel value at the position (x,y); ai, bi, ci and di denote the combinations of some of the eight symmetrical transformations; m(i) i.e. ui, vi are the location luminance values; si is the scaling coefficient; oi is the luminance offset. With the definition of equation (1), the matching search between the range blocks and the extended domain blocks is carried out by solving the minimizing problem as follows[13]

$$E(R,\hat{D}) = \min\left\| R - (s \cdot \hat{D} + o \cdot I) \right\|$$

Finally, with the equation (1) and (2), the best matched domain block can be found for each range block in the original image. The fractal image encoding would be completed when these parameters (m (i), ai, si and oi) for all the range blocks are stored. The reconstructed image can be obtained by iterating the corresponding transformation parameters on any initial image.

IV. EXPERIMENTAL RESULT

In our experimental work, we have used MATLAB platform for implementing techniques. The images selected are 8 bit gray scale plane.gif (525106 bytes, dimensions 512X512). In case of embedded zero tree (EZW) we applied have obtained results in table 1 which shows the PSNR, compression ratio for image. Figure 3 shows images of plane.gif (525106 bytes) at different level of decomposition. Similarly Table 2 shows results obtained from fractal coding that includes PSNR and CR of image. Figure 4 shows plane.gif at different size of search block in fractal image compression. Note that when size of search block increases image quality degrades in case of fractal image compression. In case of EZW we gain better compression ratio because of high redundancy in pixel values and also visual quality of image is better in it. In EZW peak signal to noise ratio (PSNR) value increases with increase of decomposition level but PSNR value of fractal image compression is much better as compared to EZW. Time of image compression in case of fractal image compression is less as compared to embedded zero tree but with increase of decomposition level in embedded zero tree encode and decode time decreases.

CONCLUSION

In this paper, the results of different image coding techniques are compared i.e. fractal Image compression and Wavelet based compression algorithm embedded zero tree (EZW). The effects of different number of decompositions, image contents and compression ratios are examined. EZW provide better visual quality and better compression ratio but it have lower value of PSNR as compare to fractal image compression. So we can conclude that objectively fractal provide better result as compare to EZW. But achieving high compression ratio and better visual quality is possible in EZW algorithm. So for better visual quality we have to choose EZW algorithm otherwise fractal image compression for better PSNR value. Fractal provides lower value of mean square error as compare to EZW. We can conclude that fractal provide better result objectively (i.e. better PSNR and lower MSE value) while EZW provide better result subjectively (i.e. better visual quality).

Experimental Results:

Original image

at level 1

at level 2

Original image

at level 1

at level 2

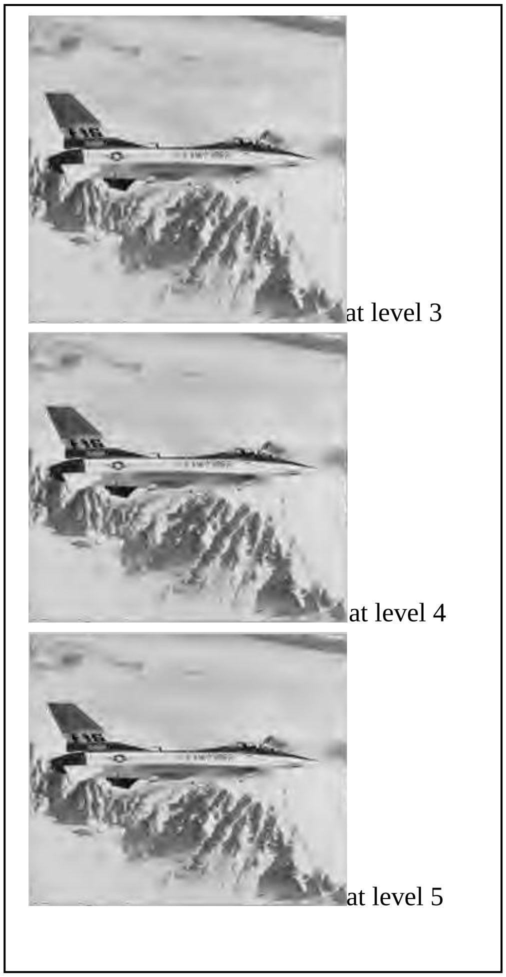

Fig: 3 images at different level of decomposition in EZW

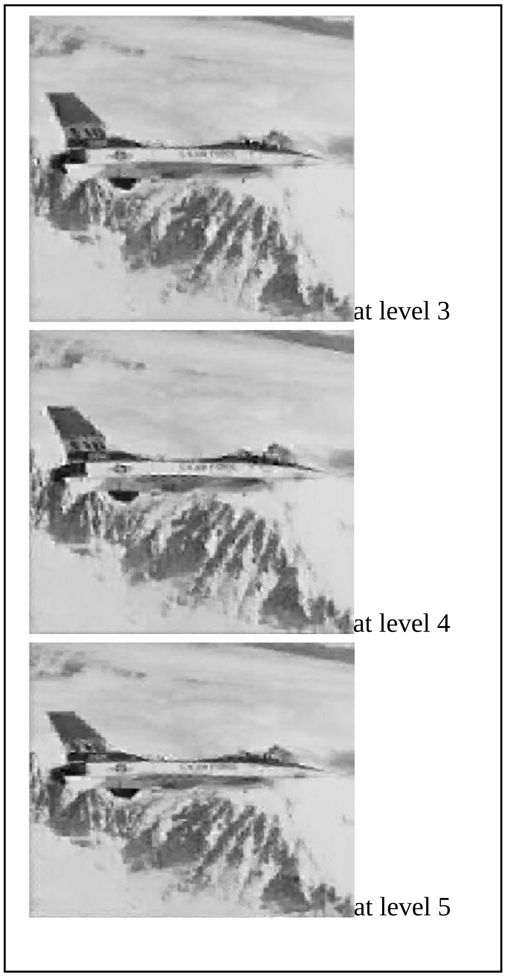

Fig: 4 images at different search block size in fractal image compression

Table I: performance evaluation of embedded zero tree algorithm

Levels	**PSNR**	**encode time(sec)**	**Decode time(sec)**	**Compressed Size**	**CR**
1	28.62	200.8610	305.6040	38671	7.7085
2	27.16	75.9930	132.7060	42979	6.9359
3	26.50	53.6940	84.9200	42779	6.9683
4	26.33	38.9000	119.7180	42315	7.0447
5	26.30	38.9320	79.1110	42185	7.0664
7	26.30	45.5960	98.4700	42321	7.0437

Table II: performance evaluation of fractal image compression algorithm

Increase in Size of block	PSNR	Compressed Size	encode	decode	CR
1	71.9026	189552	299.6060	18.1380	2.7702
2	70.8790	156611	241.2670	18.6240	3.3529
3	70.9126	152717	226.397	20.3070	3.4384
4	70.6486	157610	168.4940	18.1510	3.3317
5	70.7042	151181	175.1370	18.6720	3.4734

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