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Performance Analysis of DCSPIHT and SPIHT Algorithm for Image Compression.

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***Abstract*: This paper deals with performance evaluation of well known image compression algorithm i.e. wavelet based image compression Set Partition in hierarchical Tree (SPIHT) and DCSPIHT. DCSPIHT algorithm is the hybrid combination of DCT and SPIHT coding. Due to multi resolution nature of wavelet transforms, SPIHT provides better image compression. The techniques are implemented in MATLAB and compared using the performance parameter PSNR. Images obtained with SPIHT technique yields higher signal to noise ratio.**

***Keywords*---- DCT; SPIHT; DWT; DCSPIHT; EZW**

I. INTRODUCTION

For the wavelet transformation has good time-frequency localization properties and multi-resolution characteristic, we can use it to decompose the image signal into a number of sub-band signals which are with different spatial resolution, frequency and direction characteristics, in this way, low frequency characteristics of long and high frequency of short features can be actualized simultaneously. The image compression algorithm which is based on the wavelet transformation can overcome the block effect of the discrete cosine transform (DCT) image compression algorithm, so that it is widely used nowadays. Shapiro proposed EZW (the embedded zero-tree wavelet) algorithm[1], EZW algorithm need repeated scanning of the coefficient, the time complexity is high, encoding and decoding speed is slow, while the compression ratio is high , EZW algorithm may cause the edge blur phenomena(Gibbs effect). SPIHT[2] (set partitioning in hierarchical trees) algorithm proposed by Amir Said and W.A. Pearlman is a significant improvement of EZW algorithm, it is a amelioration based on the zero-tree structure of the EZW algorithm, SPIHT algorithm uses the smallest mean-square error criterion, the most important Wavelet coefficients are first encoded, and it has got a good compression performance. However, because SPIHT algorithm use the same encoding rules for all sub-band, it does not make full use of the characteristics of wavelet coefficients and characteristic of the different sensitivity of the visual image with the different frequency band, it result that the complexity of the encoding process is still very high, the time-consuming is very long, and encoding quality is not satisfactory. DCSPIHT [3] algorithm proposed by M. Groach and A.K. Garg is a further improvement over SPIHT; DCSPIHT algorithm uses the characteristic of different sensitivity of the visual image. DCSPIHT is the hybrid combination of DCT and SPIHT for image coding.

II SPIHT Encoding [2]

SPIHT is one of the most advanced schemes available that outperforms even the state-of-the-art JPEG 2000 in some situations. The Set-Partitioning in Hierarchical Trees (SPIHT) [2] coding operates by exploiting the relationships among the wavelet coefficients across the different scales at the same spatial location in the wavelet sub bands. In general, SPIHT coding involves the coding of the position of significant wavelet coefficients and the coding of the position of zero trees in the wavelet sub bands.

The SPIHT coder exploits the following image characteristics:

1) The majority of an image's energy is concentrated in the low frequency components and a decrease in variance is observed as we move from the highest to the lowest levels of the sub band pyramid

2) It has been observed that there is a spatial self-similarity among the sub bands, and the coefficients are likely to be better magnitude-ordered if we move downward in the pyramid along the same spatial orientation.

A tree structure, termed spatial orientation tree, clearly describes the spatial relationship on the hierarchical pyramid. Fig1 shows how the spatial orientation tree is defined in a pyramid constructed with recursive four-sub band splitting. Every pixel in the image signifies a node in the tree and is determined by its corresponding pixel coordinate. Its direct descendants (offspring) symbolize the pixels of the same spatial orientation in the next finer level of the pyramid. The tree is defined in such a manner that each node has either no offspring (the leaves) or four offspring's, which at all times form a group of 2 x 2 adjacent pixels. In Fig. 1, the arrows are directed from the parent node to its four offspring's. The pixels in the highest level of the pyramid are the tree roots and are also grouped in 2 x 2 adjacent pixels. Nevertheless, their offspring branching rule is different, and in each group, one of them has no descendants.

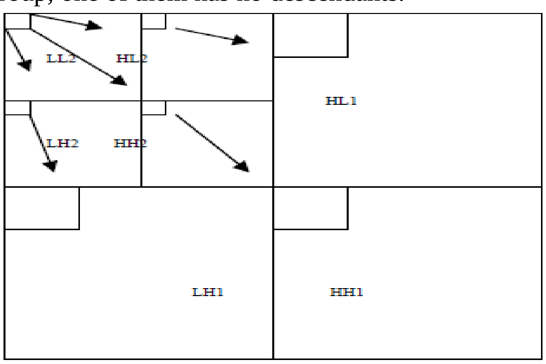

Fig 1: Tree structure used in SPIHT

The following are the sets of coordinates used to represent the coding method:

O(i, j) in the tree structures is the set of offspring (direct descendants) of a tree node defined by pixel location (i, j).

D(i, j) is the set of descendants of node defined by pixel location *(i, j)* .

L(i,j) is the set defined by L(i, j)= D(i, j) −O(i, j).

Except for the highest and lowest pyramid levels, the set partitioning trees has,

O(i, j) = {(2i,2 j),(2i,2 j +1), (2i +1,2 j), (2i +1,2 j +1)}

The rules for splitting the set (e.g. when found significant),

1) The initial partition is formed with the sets (i, j) and D (i, j), for all (i, j) ЄH.

2) If D (i, j) is significant, then it is partitioned into L (i, j) plus the four single-element sets with (k, l)ЄO(i, j).

3) If L (i, j) is significant, then it is partitioned into the four sets D (k, l) with (k, l)ЄO(i, j). The significant values of the wavelet coefficients modeled in the spatial orientation tree are stored in three ordered lists namely.

4) LIS, List of insignificant sets**:** contains the set of wavelet coefficients defined by tree structures, and found to have magnitude smaller than a threshold (are insignificant). The sets exclude the coefficient corresponding to the tree or all sub tree roots, and have at least four elements. The entries in LIS are sets of the type *D*(*i*, *j*) (type A) or type *L*(*i*, *j*) (type B).

5) LIP, List of insignificant pixels**:** contains the individual coefficients that have magnitude smaller than the threshold.

6) LSP, List of significant pixels**:** contains the pixels that are found to have magnitude larger than the threshold (are significant). During the sorting pass, the pixels in the LIP that were insignificant in the previous pass are tested, and those that emerge significant are moved to the LSP. Then, the sets are sequentially assessed along the LIS order, and when a set is found significant it is removed from the list and partitioned. The new sets with more than one element are added back to LIS, while the one element sets are added to the end of LIP or LSP, according to their being significant. The significance function is defined as follows:

$$S_n(T) = \begin{cases} 1, & \max\{c_{i,j}\} \geq 2^n \\ & (i,j) \in T \\ 0, & otherwise \end{cases}$$

A. Algorithm

1) *Initialization***:**

output n = $\lfloor \log_2(\max_{(i,j)}\{|c_{i,j}|\})$

Set the LSP as an empty list, and add the coordinates $(i,j) \in H$ to the LIP, and only those with descendants also to the LIS, as type A entries.

2) *Sorting Pass:*

2.1.) for each entry (i, j) in the LIP do :

2.1.1.) output Sn (i, j);

2.1.2.) if S_n (i, j) = 1 then move (i, j) to the LSP and output the sign of $c_{i,j}$;

2.2.) for each entry (i, j) in this LIS do:

2.2.1.) if the entry is of type A then

- Output S_n (*D*(i, j));
- if S_n (*D*(i, j)) = 1 then
  for each $(k,l) \in O(i,j)$ do :
  - output Sn (k,l);
  - if S_n (k,l) = 1 then add (k, l) to the LSP and output the sign of $C_{k,l}$
  - if S_n (k,l) = 0 then add (k,l) to the end of LIP;
    - if L(i, j) $\neq$ 0 then move (i, j) to the end of the LIS,as an entry of type B, and go to Step 2.2.2); otherwise, remove entry (i, j) from the LIS;

2.2.2.) if the entry is of type B then

- Output S_n (L(i, j));
- if S_n (L(i, j)) = 1 then
  - add each (k, l) ∈O(i, j) to the end of the LIS as an entry of type A;
  - Remove (i, j) from the LIS.

3) *Refinement Pass*:
For each entry (i, j) in the LSP, expect those included in the last sorting pass (i.e., with same n*)*, output the *nth* most significant bit of $|C_{i,j}|$;

4) *Quantization-Step Update*:
Decrement n by 1 and go to Step 2.

Some of the advantages of SPIHT encoding include:

(i) Allows a variable bit rate and rat distortion control as well as progressive transmission

(ii) An intensive progressive capability – we can interrupt the decoding (or coding) at any time and a result of maximum possible detail can be reconstructed with one-bit precision.

(iii) Very compact output bit stream with large bit variability no additional entropy coding or scrambling has to be applied.

III DCSPIHT algorithm for image compression [3]

Human eye sensitivity to different frequencies is different [4], it is not sensitive to gray-scale error, but the human eye is particularly sensitive to the image edge features such as, through the SPIHT algorithm to improve transformation process; increase the edge threshold, the human visual characteristics and SPIHT algorithm pay more attention to image edge information. At the same time, the DCT coding and SPIHT algorithm are combined to achieve hybrid DCT and SPIHT coding.

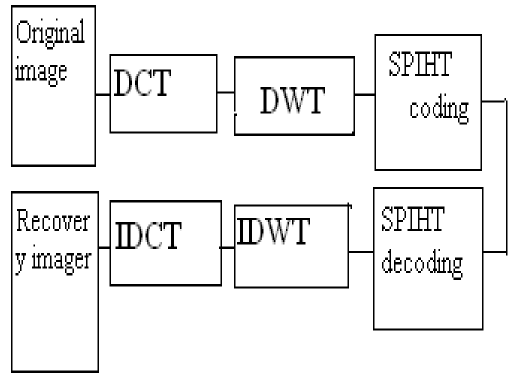

Fig 2: DCSPIHT algorithm coding /decoding diagram

This DCSPIHT algorithm combines two different techniques DCT and SPIHT to achieve better image compression because every image consists of low frequency and high frequency component. As we know DCT is the technique which is more efficient for low frequency component and SPIHT gives better result for high frequency component.

As see in figure 2, first of all original image is pass through the DCT coding after that we create the wavelet transformation of DCT output,

TABLE 1
PSNR WITH DIFFERENT BIT RATE

Image (512× 512)	Bit rate	PSNR (dB)	
		DCSPIHT	SPIHT
LENA	0.25	31.400	31.805
	0.50	35.160	35.045
	0.65	36.000	36.456
Girl 512	0.25	25.800	27.300
	0.50	29.450	30.000
	0.65	30.750	31.150
Gorilla	0.25	20.050	22.30
	0.50	23.75	24.20
	0.65	24.85	25.60

this dwt output then encoded with SPIHT technique, now overall coded data is to be transmitted. In the receiver side received data is to be decoded.

IV EXPERIMENTAL RESULTS

This section, present the results obtained from the experimentation to illustrate the effectiveness of the two image compression techniques. The presented schemes are implemented in MATLAB (Matlab 7.8). These two algorithms are evaluated on natural dyadic square (512 x 512) grayscale images. The test images used in the experiments include: Lena, Girl 512 and Gorilla. The quality of the reconstructed images is measured in terms of PSNR value and the efficiency of the presented hybrid scheme is measured in terms of its compression ratio. The PSNR in decibels (dB) is defined as [5] in table 1:

$$PSNR = 20\log_{10}\frac{MAX}{RMSE} = 20\log_{10}\frac{255}{\sqrt{\frac{1}{NM}\sum_{x=1}^{N}\sum_{y=1}^{M}[f(x,y)-f'(x,y)]^2}}$$

Where, MAX is the image depth. N and M are the width and height of the image in pixels. f is the original image and f' is the reconstructed image

V Conclusions

In this paper, we have presented a comparative study of two different image compression techniques. SPIHT is primarily a wavelet-based image compression scheme. In SPIHT, the image is first converted into its wavelet transform and then the wavelet coefficients are fed to the encoder. In DCSPIHT the input image has been subjected to DCT coding then the output is decomposed using biorthogonal wavelet transform. This decomposed output further compressed using SPIHT encoding. The experimental results have portrayed the effectiveness of the two different techniques of image compression.

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