Improvement in Traditional Set Partitioning in Hierarchical Trees (SPIHT) Algorithm for Image Compression

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Abstract— In this paper, an improved SPIHT algorithm based on Huffman coding and discrete wavelet transform for image compression has been developed. The traditional SPIHT algorithm application is limited in terms of PSNR and Compression Ratio. The improved SPIHT algorithm gives better performance as compared with traditional SPIHT algorithm; here we used additional Huffman encoder along with SPIHT encoder. Huffman coding is an entropy encoding algorithm uses a specific method for choosing the representation for each symbol, resulting in a prefix code. The input gray scale image is decomposed by 'bior4.4' wavelet and wavelet coefficients are indexed and scanned by DWT, then applied to encode the coefficient by SPIHT encoder followed by Huffman encoder which gives the compressed image. At receiver side the decoding process is applied by Huffman decoder followed by SPIHT decoder. The Reconstructed gray scale image looks similar to the applied gray scale image.

Keywords— ***LIP, LSP, LIS, PSNR, Average Difference, MSE, Compression Ratio.***

I. INTRODUCTION

Image compression is the process of encoding information using fewer bits. Compression is useful because it helps to reduce the consumption of expensive resources, such as hard disk space or transmission bandwidth. On the downside, compressed data must be decompressed, and this extra processing may be detrimental to some applications. For instance, a compression scheme for image may require expensive hardware for the image to be decompressed fast enough to be viewed as its being decompressed (the option of decompressing the image in full before watching it may be inconvenient, and requires storage space for the decompressed image). The design of image compression schemes therefore involves trade-offs among various factors, including the degree of compression, the amount of distortion introduced (if using a lossy compression scheme), and the computational resources required to compress and uncompress the data. Image compression is an application of data compression on digital images. It minimizes the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level. The reduction 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 downloaded from web pages. There are basic two types of image compression one is Lossy compression most commonly used to compress multimedia data (audio, video, still images), especially in applications such as streaming media and internet telephony and second one is Lossless compression methods may also be preferred for high value content, such as medical image or image scans made for archival purposes.

There are different methods used for compressions such as JPEG, JPEG2000, EZW, and SPIHT. In this paper we developed Improved SPIHT algorithm followed by Huffman encoding for image compression and results will be compared with Traditional SPIHT algorithm in terms of PSNR, Compression Ratio, MSE and Average Difference.

II. SPIHT COMPRESSION SCHEME

In 1996 Said and Pearlman developed a simple and fully embedded image coding algorithm based on set partitioning in hierarchical trees (SPIHT) concept. The SPIHT algorithm applies the set partitioning rules, as defined above on the sub-band coefficients. The algorithm is identical for both encoder and decoder and no explicit transmission of ordering information, as needed in other progressive transmission algorithms for embedded coding, are necessary. This makes the algorithm more coding efficient as compared to its predecessors. Both the encoder and decoder maintain and continuously update the following three lists, viz. [1]

- List of Insignificant Pixels (LIP)
- List of Significant Pixels (LSP)
- List of Insignificant Sets (LIS)

The Spatial orientation tree is generated by filter component LL (Low-Low), LH (Low-high), HH(High-high), HL(High-low) These are coefficient location lists that contain their coordinates after the initialization; the algorithm takes two stages for each level of threshold. The sorting pass (in which lists are organized) and the refinement pass (which does the actual progressive coding transmission). In all lists each entry is identified by a coordinate (i, j) which in the LIP and LSP represents individual pixels and in the LIS represents either the set D (i, j) or L (i, j). To differentiate between them it can be concluded that a LIS entry is of type A if it represents D (i, j) and of type B if it represents L (i, j); during the sorting pass the pixels in the LIP-which were insignificant in the previous pass-are tested and those that become significant are moved to the LSP. Similarly, sets are sequentially evaluated following the LIS order, and when a set is found to be significant it is removed from the list and partitioned. The new subsets with more than one element are added back to the LIS, while the single coordinate sets are added to the end of the LIP or the LSP depending whether they are insignificant or significant respectively. The LSP contains the coordinates of the pixels that are visited in the refinement pass. SPIHT adopts the serial processing approach [2], [3].

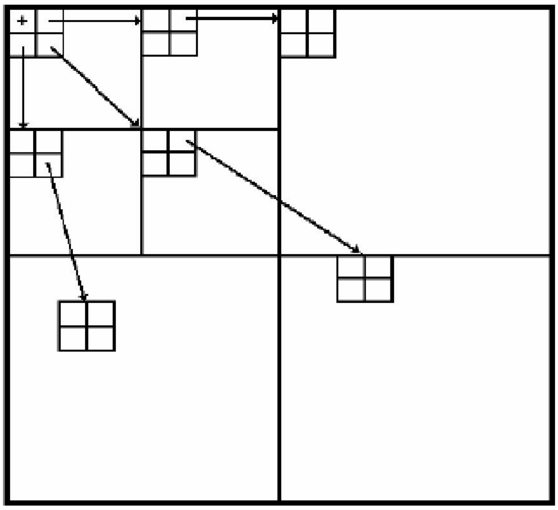


Fig.1 Hierarchical Tree Structure of SPIHT

O (i, j):Offspring of node (i, j), D(i, j): All descendants of node (i, j), L(i, j): D(i, j)-0(i, j), H: Tree roots

The spatial orientation tree, illustrated in fig.1 defines the spatial relationship between the sub bands in the form of a pyramid composed of a recursive four band split. Each node of the tree corresponds to a pixel and is identified by its pixel coordinate. Other than the leaves, each node of the tree has four offspring corresponding to the pixel at the same position in the next finer level of the pyramid of same orientation, as shown by arrows in the diagram. The only exceptional case is the LL sub band existing at the highest level of pyramid. Pixels in this sub band form the root and groups of adjacent 2x2 pixels are composed. Other than one of the pixels (marked as '*') out of these four, all remaining three pixels have their four offspring in the HL, LH and HH sub bands of the same scale, as shown. One out of the four is obviously left out since only three sub bands exist for determining the descendants.

III. IMPROVED SPIHT ALGORITHM

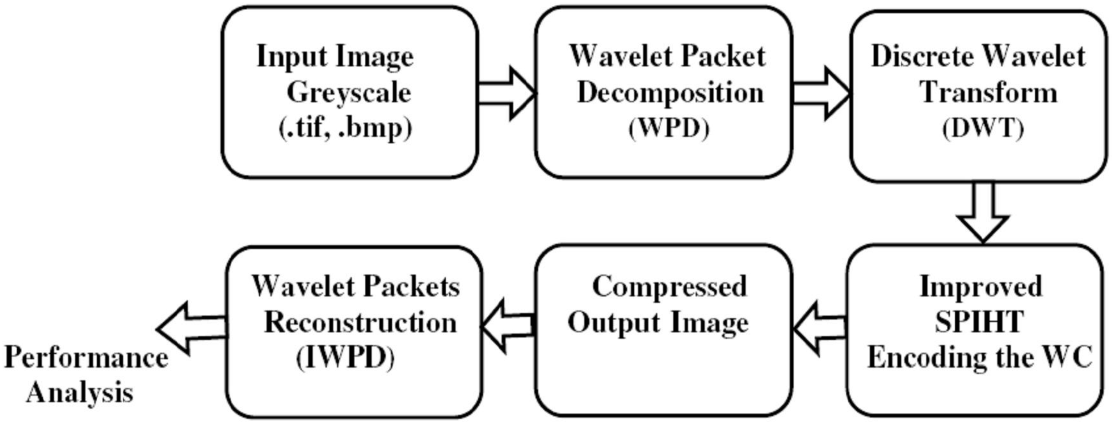


Fig.2. Implemented Improved SPIHT Algorithm

Steps:

- Initialize the Level counter = 1
- Let the current node = Input image.
- Decompose current node using wavelet packet Transformation.
- Find the entropy of current node.
- Find the entropy of decomposed node.
- Compare the entropy of parent node with the sum of the entropy of child node.
- Encode discrete wavelet packet coefficients using SPIHT Encoder Followed by Huffman Encoding.

A. Discrete Wavelet Transform:

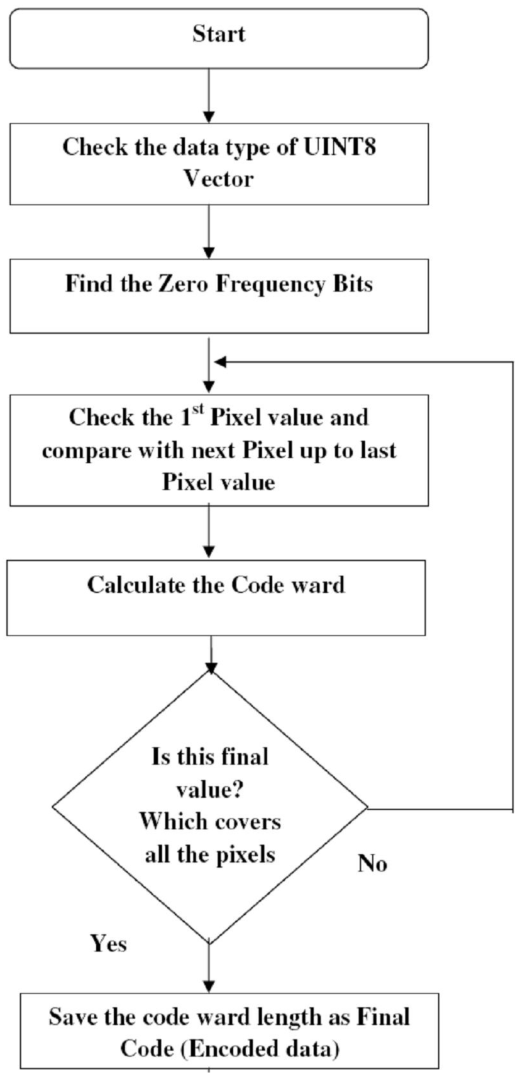
Wavelet analysis represents the next logical step, a windowing technique with variable-sized regions [4]. Discrete wavelet transforms (DWT), which transforms a discrete time signal to a discrete wavelet representation. It converts an input series x_0 , x_1, ...x_m, into one high-pass wavelet coefficient series and one low-pass wavelet coefficient series (of length n/2 each) given by:

$$H_i = \sum_{m=0}^{k-1} x_{2i.m} . S_m(z) \qquad (1)$$

$$L_i = \sum_{m=0}^{k-1} x_{2i.m} . t_m(z) \qquad (2)$$

Where, $s_m(Z)$ and $t_m(Z)$ are called wavelet filters, K is the length of the filter, and i=0, ..., [n/2]-1. In practice, such transformation will be applied recursively on the low-pass series until the desired number of iterations is reached. Lifting schema of DWT has been recognized as a faster approach The basic principle is to factorize the polyphase matrix of a wavelet filter into a sequence of alternating upper and lower triangular matrices and a diagonal matrix . This leads to the wavelet implementation by means of banded-matrix multiplications.

B. Huffman Encoding



Huffman coding is an entropy encoding algorithm uses a specific method for choosing the representation for each symbol, resulting in a prefix code (sometimes called "prefix-free codes", that is, the bit string representing some particular symbol is never a prefix of the bit string representing any other symbol) that expresses the most common source symbols using shorter strings of bits than are used for less common source symbols. Huffman was able to design the most efficient compression method of this type: no other mapping of individual source symbols to unique strings of bits will produce a smaller average output size when the actual symbol frequencies agree with those used to create the code. The running time of Huffman's method is fairly efficient; it takes operations to construct it. A method was later found to design a Huffman code in linear time if input probabilities (also known as weights) are sorted. For a set of symbols with a uniform probability distribution and a number of members which is a power of two.

C. Advantages of DWT over DCT

- No need to divide the input coding into non overlapping 2-D blocks, it has higher compression ratios avoid blocking artifacts.
- Allows good localization both in time and spatial frequency domain.
- Transformation of the whole image introduces inherent scaling
- Higher compression ratio
- Higher flexibility: Wavelet function can be freely chosen.
- No need to divide the input coding into non-overlapping 2-D blocks, it has higher compression ratios avoid blocking artifacts.

IV. PERFORMANCE MEASUREMENT AND RESULTS

The performance of Traditional SPIHT and Improved SPIHT algorithm is compared in terms of PSNR, MSE, Compression Ratio and Average Difference between original image and reconstructed image quality using different grayscale images.

TABLE 1
COMPARATIVE TABLE OF TRADITIONAL SPIHT & IMPROVED SPIHT COMPRESSION ALGORITHM

Gary Scale Image	Comp. Rate	Traditional SPIHT Algorithm with Decomposition level=5				Improved SPIHT Algorithm with Decomposition level=5			
		PSNR in dB	CR	MSE	AD	PSNR in dB	CR	MSE	AD
Lena 512x512	0.2	31.62	9.1992	44.76	0.0178	32.3691	29.0374	33.3819	0.0044
	0.3	33.77	6.1328	27.26	0.0234	34.4491	19.0639	20.6784	0.0027
Couple 512x512	0.2	29.53	9.3999	72.52	0.0355	29.6079	29.0366	71.1695	0.0355
	0.3	31.6	6.2666	44.98	0.0043	31.6724	19.1538	44.2425	0.0043

V. CONCLUSION

In this paper we presented an improved approach for image compression based on the SPIHT algorithm. The implemented compression algorithm based on Huffman coding will give better result in terms of PSNR, Compression Ratio compared with Traditional SPIHT image compression algorithm. The reconstructed image quality of improved algorithm is better than traditional algorithm. The above improved algorithm will enhance the compression ratio nearly equals to 3 times greater than the traditional SPIHT algorithm without reducing the PSNR but slightly affecting the performance speed of algorithm. The results are tested using 512x512 gray scale images.

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