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OVERVIEW OF SPIHT BASED IMAGE COMPRESSION ALGORITHM

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ABSTRACT

In today's World image compression technique is very essential because in this digitized world there is lot of use of image transmission which needs lots of space and time for transmission. Therefore, there are certain techniques which are used for image compression, in this paper we are introducing the Set Partitioning in hierarchical trees(SPIHT) image compression algorithm whichis wavelet based computationally very efficient, has low computational complexity, and generates an embedded compressed bit-stream that can be efficiently decoded at several data rates (qualities). And offers good compression ratios, fast execution time and good image quality.here we have given a detail working example of SPIHT for better understanding.

KEYWORDS: Image Compression, SPIHT, DWT MSE,MSPIHT, PSNR

I. INTRODUCTION

Digital image compression is essential because day by day various activities like internet teleconferencing, multimedia, high definition television technologies, satellitecommunication are growing rapidly.Hence it requires large amount of space for storing Digital Image Component and more time for transmission,thus it is a major problem.Solution to this problem is to compress the information so that the storage space and transmission time will be reduced. Image compression is possible because images contains redundant information. Compression is achieved through redundancy and irrelevancy reduction, redundancy means duplication and irrelevancy means the part of the image information that will not be noticed by human visual system.

Type of compression:

a. Lossless compression
b. Lossy compression

In lossless Compression the image is compressed by encoding the information from the original image so that when the image is decompressed it will be exactly identical to the original image without loss of data.

In lossy compression the compressed image contains degradation with respect to the original image, the compressed image is similar to the original image but some information concerning the image has been loss.

Wavelet transform are the most powerful and widely used tool in the field of image compression, in past few year wavelet transforms become popular in the field of image processing due to its ability to effectively represent and analyse data. Image compression algorithms based on Discrete wavelet transform such as Embedded Zero Wavelet (EZW) which is based on progressive coding to compress an image into a bit stream with increasing accuracy. Set partitioning in hierarchical trees (SPIHT)is wavelet based computationally vary fast and among the best image compression based transmission algorithm that offers good compression ratios,image quality and fast execution time.

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II. DISCRETE WAVELET TRANSFORM

To Achieve Image Compression wavelet transform provides a compact multiresolution representation and has excellent energy compaction property to exploit redundancy. DWT can be implemented using two-channel wavelet filter bank in a recursive fashion.

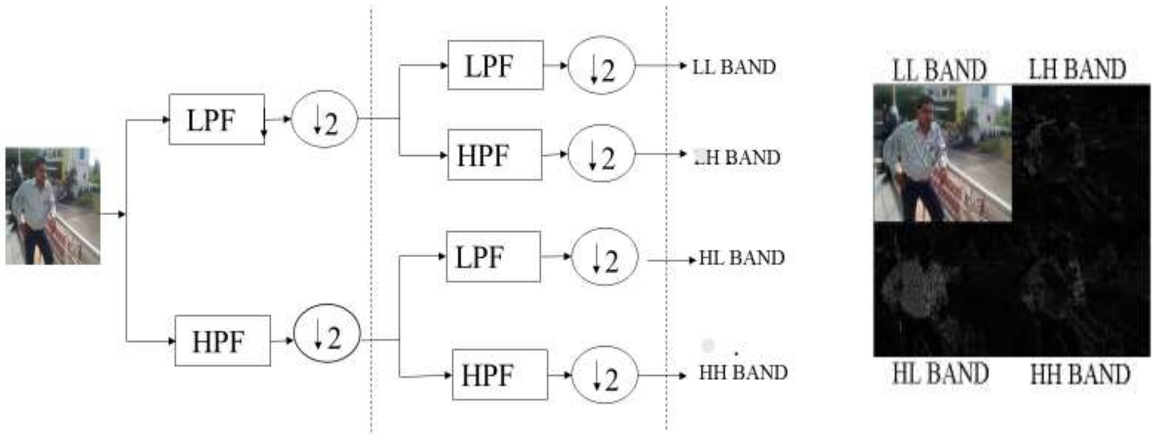

Figure 1 First -Level decomposition of original Image

As shown in the figure 1 Original Input Image Firstly Is Scan in Horizontal Direction and then pass through low pass Decomposing filter and high pass Decomposing filter producing low frequency and high frequency data in horizontal direction, and this data is then scan in vertical direction then pass through low pass Decomposing filter and high pass Decomposing filter producing different frequency Sub band. The transform generates sub - band LL, LH, HL, HH. most of the energy is concentrated in low frequency sub band LL, where remining three sub band LH, contain detail information of the image in vertical directions, HL contain detail information of the image in horizontal directions and HH contain detail information of the image in diagonal directions for high level decomposition, DWT can be applied again to the LL sub-band recursively in a similar way but will not consider the other three sub band which are HL, LH, HH The Fig.2 shows the three level decomposition of the original image and its outputs is shown in the fig 3. (a), (b).

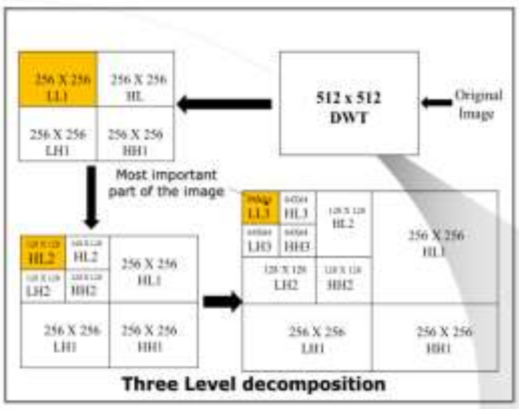

Figure 2 Three Level decomposition of original Image

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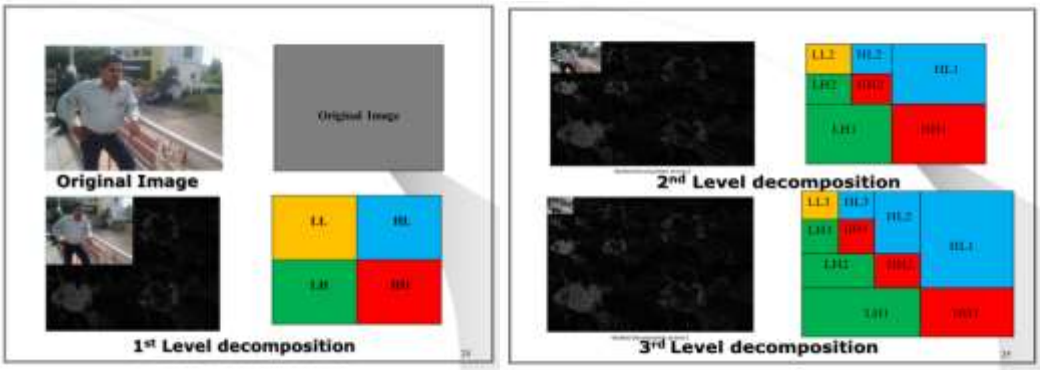

(a) **(b)**

Figure 3 Output of Three Level decomposition.

III. SPIHT CODER AND DECODER: -

As shown in the Fig.4 show the block diagram of the SPIHT coder is given below. The upper half represents the Decomposition while the lower block performs the Reconstruction. The original image is passed to DWT block which outputs Wavelet Coefficients of the original image. Then these coefficients are passed to the SPIHT encoder which encodes the output and gives data in bit stream manner. Now this bit stream is sent to the SPIHT Decoder Which Decodes The bit stream and passes to the IDWT block to get the Reconstructed image

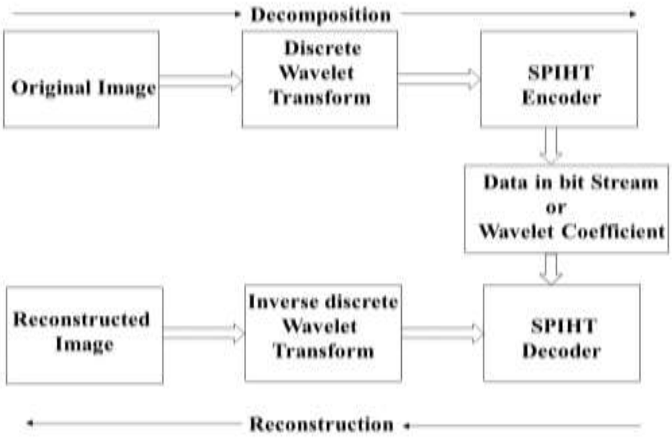

Figure 4 BlockDiagram of Encoder &Decoder SPIHT Algorithm

SPIHT algorithm: -

SPIHT (Set Partitioning in Hierarchical Trees)is an image compressing algorithm associated with DWT, it uses principle of self-similarity across scaleas an EZW.It is a method of coding and decoding the wavelet transform of an image. It has numerous attractive features, so it is an extremely powerful image compression algorithm.The SPIHT algorithm partitions the decomposed wavelet into significant and insignificant partitions based on the following function:

$$S_n(T) = 1 \quad \max_{(i,j)\epsilon TM}\{|C_{(i,j)}|\} \geq 2^n$$
$$0 \text{ otherwise}$$

Hear $S_n(T)$ is the significance of a set of coordinate T and $C_{(i,j)}$ is thecoefficient value at coordinate (i, j).

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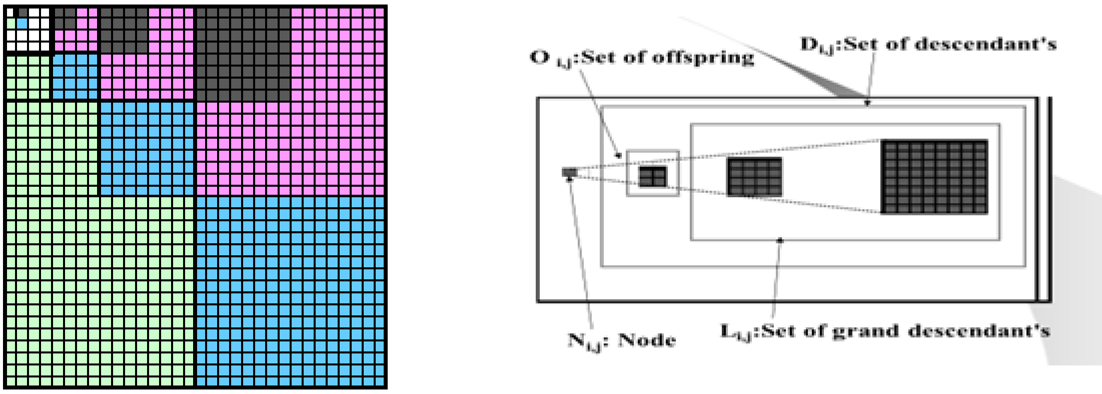

Figure 5 SOT of coefficients in SPIHT

The SPIHT algorithm defines four types of sets, which are sets of coordinates of coefficients:
1) O (i, j) is the set of coordinates of the off springs of the wavelet coefficient at the location (i, j).
2) D (i, j) is the set of all descendants of the coefficients at the location (i, j).
3) H is the set of all root nodes.
4) L (i, j) is the set of coordinates of all descendants of the coefficients at the location (i,j).

Flow chart of SPIHT: -

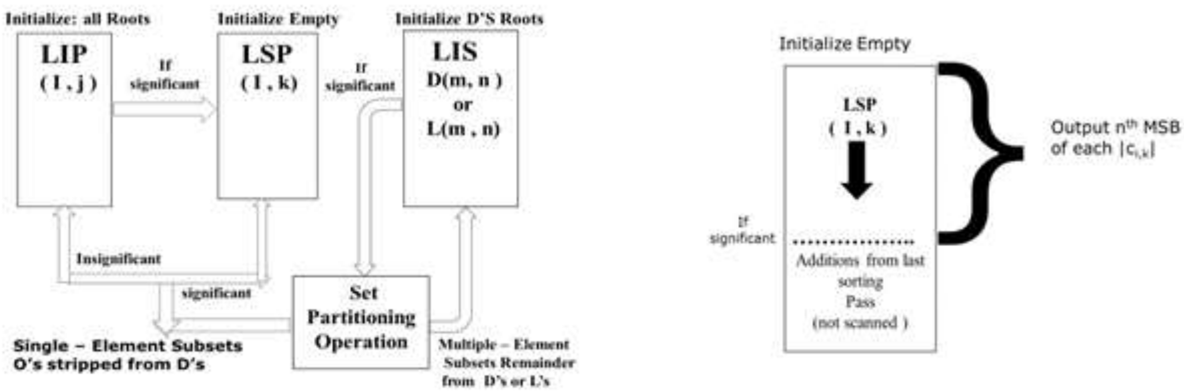

Figure 6Operation of SPIHT

Step 1: Initialize

Initialize the threshold and order list Assign coefficients of all the root node in low-pass sub-band to LIP, all the trees are assigned to LIS and LSP is initialized to be an empty set.

Step 2: Sorting Pass

The aim is to encode the important coefficient of current bit. There are two main steps:

A) Check all the wavelet coefficients in LIP to determine whether they are important coefficients:

1) If it is yes, then output "1" and the sign bit, positive or negative sign bits of wavelet coefficients are represented by "1" and "0", and then remove the coefficient from LIP and add to the end of order list LSP.
2) If it is not, we do not need to remove it from the list of LIP and give a direct output of "0".

B) According to the type of trees, we shall check all the important trees in LIS:

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Step 3: Refinement Pass
The aim is output but not the improving position of important factor in generated in the process of scanning. For each node (i, j) in LSP, if (i, j) is not just added during the scanning process, then absolute value |Ci, j| of the output of this node coefficient can be transmitted.

Step 4: **Update the threshold**
The maximum number of bits required to represent the largest coefficient in the spatial orientation tree is obtained and represented by n, which is $n = |\log_2^{c\ max}|$, where c max is the maximum value of coefficient. Update the threshold by decrement n by 1 and conduct the next level coding (back to step 2)

SPIHT introduces three lists of wavelet coefficients:

- List of insignificant pixels(LIP): - It contains individual coefficients that have magnitudes smaller than the thresholds.i.e. magnitudes< thresholds.
- List of significant pixels(LSP): -It is a list of pixels found to have magnitudes larger than the threshold (significant).i.e. magnitudes > thresholds.
- List of insignificant sets(LIS): -It contains set of wavelet coefficients that are defined by tree structures and are found to have magnitudes smaller than the threshold.

WORKING EXAMPLE: -

Table1:Wavelet coefficients of the image

34	**0**	**1**	**-1**
0	**0**	**-1**	**1**
4	**-4**	**10**	**-6**
-4	**4**	**6**	**-10**

Step1:
To find the number of passes in the encoding process,let us denote the maximum number of passes by the letter n. The value of n is given

$$n = |\log_2^{C\ max}|$$

Where C max is the maximum value of the coefficient.

$$n = |\log_2^{34}|$$
$$n = 5$$

Initially, in the LIP there are four insignificant pixels: 34,0,0 and 0. And in the LIS,there are three sets of values (01,10 and 11). Here 01 denotes four values (1, -1, -1 and 1), 10 denotes the four values (4, -4, -4 and 4), and 11 contains the four values (10, -6, 6 and -10). And initially, the LSP is empty.

LIP	LSP	LIS
(0, 0) = 34	Empty	(0, 1)D = (1, -1, -1, 1)
(0, 1) = 0		(1, 0)D = (4, -4, -4, 4)
(1, 0) = 0		(1, 1)D = (10,-6, 6 -10)
(1, 1) = 0		

Figure7: Initial Sorting and refinementpass

First pass:
In the first pass, the value of n=5, find the initial threshold value (T_0). $T_0 = 2^n = 2^5 = 32$. Now compare the values of LIP with thethreshold T_0. If the LIP values are greater than T_0 then the values will be moved into LSP; otherwise the values of LIPwill remain same. Here, the first value of LIP is 34, which is greater than T_0. So, the

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value of 34 is moved into LSP. Andthe code 10 is sent to theencoding bit stream. The remaining values of LIP are lesser than T_0. So, for each value of LIP, the bit like 0 is sent. For this case, the lesser values are three. So, it will send the code 000 to the encoding bit stream. After comparing the LIP with the initial threshold, the encoded bit stream is {10000}. Now check the LIS, if it has any value greaterthan T_0. Thenone alert bit like (1) will be sent to the encoded bit stream. Otherwise it will send the one (0) bit to each set. In this case, the set 01, 10, and 11 have the values lesser than T_0. So, it will send the bits (000) to the encoded bit stream. After the first pass, the values in the three lists are as follows:

LIP	LSP	LIS
(0, 1) = 0	(0, 0) = 34	(0, 1)D = (1, -1, -1, 1)
(1, 0) = 0		(1, 0)D = (4, -4, -4, 4)
(1, 1) = 0		(1, 1)D = (10,-6, 6 -10)

Encoded Bit stream is =

10	0	0	0	0	0	0

= 8bits

Figure8: First Sorting and refinement pass

Second pass:
In the second pass, the value of n is decremented by 1.So, the corresponding threshold value reduces to 16(i.e., 2^4=16). The process is repeated by examining the contents of LIP. There are three elements in LIP. Each is insignificant at this threshold, and so we transmit three 0s (000). The next step is to examine the contents of LIS. The first element of LIS is the set containing the descendants of the coefficient at location (01). Of this set, the values (1, -1, -1 and 1) are insignificant and so transmit 0. Looking at the other elements of LIS (10 and 11), we can clearly see that both of these are insignificant at this level; hence send a 0 for each.

Refinement pass
In the refinement pass we examine the contents of LSP from the previous pass. There is only one element in there that is not from the current sorting pass and it has a value of 34 the forth MSB of 34 (100010) is 0 therefore we transmit 0 and complete this pass.

In the second pass we have transmitted 8 its 10000000 after the third pass the values of lists as follows:

LIP	LSP	LIS
(0, 1) = 0	(0, 0) = 34	(0, 1)D = (1, -1, -1, 1)
(1, 0) = 0		(1, 0)D = (4, -4, -4, 4)
(1, 1) = 0		(1, 1)D = (10,-6, 6 -10)

Encoded Bit stream is =

10	0	0	0	0	0	0

= 8bits

Figure9: Second Sorting and refinement pass

Third pass:
The third pass proceeds with n=3, with n=3 the threshold is 8, (i.e., 2^3=8). Again, we pass examining the contents of LIP. There are three elements in LIP. Each is insignificant at this threshold so we transmit three 0s (000). The next step is to examine the contents of LIS. The first element of LIS is the set containing the descendants of the coefficient at location (01). Of this set, the values (1, -1, -1 and 1) ae insignificant and so transmit one 0. Looking at the other elements of LIS (10 and 11), we can clearly see that 10 is insignificant at this level; therefore, we send a 0 the next set 11 both 10 and -10 are significant at this value of the threshold in theother word the set 11 is significant we this by sending a 1 for the alert bit the 11 descendants have a value of 10 which is greater than 8 hence it is significant positive, and so we send a 1 followed by a 0 (10) The next two offspring's are both insignificant at this level therefore we move these to LIP and transmit a 0 for each.The

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fourth offspring's which has a value of -10 is significant but negative. So, we send 1 followed by a 1(11). We move the coordinates of two (10 and -10) to LSP.

Refinement pass:
In the refinement pass we examine the contents of LSP from the previous pass. There is only one element in there that is not from the current sorting pass and it has a value of 34. Thethird MSB of 34 (100010) is 0 therefore we transmit a 0 and complete this pass in the thirdpass we have transmitted 13 bits 0000011000110. After the third pass the values of lists as follows:

:

LIP	LSP	LIS
(0, 1) = 0	(0, 0) = 34	(0, 1)D = (1, -1, -1, 1)
(1, 0) = 0	(2, 2) = 10	(1, 0)D = (4, -4, -4, 4)
(1, 1) = 0	(3, 3) = -10	
(2, 3) = -6		
(3, 2) = 6		

Encoded Bit stream is =

0	0	0	0	0	1	10	0	0	1	10

13bits

Figure 10: Third Sorting and refinement pass

Fourth pass:
The fourth pass proceeds with n=2 as the threshold is now smaller 4, (i.e., 2^2=4), there are more coefficient that are deemed significant and we end up sending 28 bits.Again, we pass examining the contents of LIP. There are five elements in LIP. The first three values are insignificant at this threshold, so we transmit three 0s (000). The next two values are significant, but one value (-6) is significant negative, so we send 11. The other coefficients (6) is significant positive so we transmit 10 bits these two values are moved to LSP the next step examine the contents of LIS. The first element of LIS is the set containing the descendants of the coefficient at location (01). Of this set, the values (1, -1, -1 and 1) are insignificant and so transmit one 0. Looking at the other elements of LIS (10), we can clearly see that 4 is insignificant at this level; in this set all the values (4, -4, -4 and 4) are insignificant at this value of threshold in other word the set 10 is significant. we signal this by sending a 1 for the alert bit the 10 descendants have a value of 4 which is greater than 4 hence it is significant positive, and so we send a 1 followed by a 0 (10) The 10 descendants have a third value is of -4 which is greater than 4 but it also negative so it significant negative and hence we send a 1 followed by a 1 (11). Finally, the last coefficients of 10 is 4 which is greater than the threshold so it is significant positive and we transmit 10 bits the 10-part coefficients are move into LSP.

LIP	LSP	LIS
(0, 1) = 0	(0 , 0) = 34	(0, 1)D = (1, -1, -1, 1)
(1, 0) = 0	(2 , 2) = 10	
(1, 1) = 0	(3 , 3) = -10	
	(2 , 3) = - 6	
	(3 , 2) = 6	
	(2 , 0) = 4	
	(2 , 1) = - 4	
	(3 , 0) = - 4	
	(3 , 1) = 4	

Encoded Bit stream is =

0	0	0	11	10	0	1	10	11	11	10

17bits

Figure11:ForthSorting and refinement pas

Measuring Parameter: -
The performance parameters are measured in terms of CR, PSNR and MSE.

A. Compression Ratio
Compression Ratio (CR) is the ratio between post compression file size and pre-compressionfile size. For any algorithm compression Ratio (CR) should be higher

$$\text{Compression Ratio} = \frac{\text{Size after compression}}{\text{Size before compression}}$$

B. Peak Signal to Noise Ratio (PSNR)
PSNR is defined as the ratio between maximum signal power to noise encountered in signal. PSNR should be higher for any algorithm

$$\mathbf{PSNR=10\ Log_{10}(Q\ X\ Q\ /MSE)\ |db.|}$$

Where Q X Q is the resolution of the uncompressed image.

C. Mean Square Error (MSE)
Mean Square Error defined the Mean Squared Error between the compressed image and original image. MSE should be lower for any algorithm. If MSE is 0 that"s mean compressed image is similar to uncompressed image and is given by

$$MSE = \frac{1}{NxM}\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}[X(i,j) - Y(i,j)]^2$$

IV. SIMULATION RESULT OF SPIHT

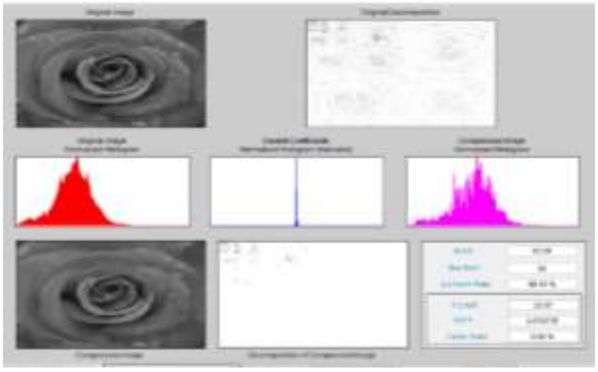

Figure 12: Simulation result of SPIHT

V. CONCLUSION
SPIHT is simple and fast compression method as compared to other compression techniques, in this paper Image is considered and wavelet transform is applied on the image and wavelet decomposition is doneby using SPIHT algorithms in terms size, compression ratio, mean square error, peak signal to noise ratio are analysed.

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