International Journal of Advanced Computer Research (ISSN (print): 2249-7277 ISSN (online): 2277-7970)
Volume-3 Number-4 Issue-13 December-2013

SPIHT Algorithm with Huffman Encoding for Image Compression and Quality Improvement over MIMO OFDM Channel

Dnyaneshwar.K[1], CH.Suneetha[2]

Abstract

In this paper, Compression and improving the Quality of images during the transmission using SPIHT algorithm combined with Huffman encoding over OFDM channel has been proposed. Initially decompose the image in to different level, the compressed coefficients are arranged in descending order of priority and mapped over the channels. The coefficients with lower importance level, which are likely to mapped over the bad sub channels, are discarded at the transmitter to save power without significant loss of reception quality. Next SPIHT embedded encoder algorithm combined with Huffman encoder is applied for further compression. Finally the Huffman and SPIHT decoding of the embedded encoder is done. In this technique reduce the number of encoding bits and improving the Quality of image.

Keywords

DWT, Huffman, SPIHT, OFDM channel.

1. Introduction

Orthogonal Frequency Division Multiplexing (OFDM)is a multi-carrier modulation scheme having excellent performance which allows overlapping in frequency domain. In OFDM, individual sub channels are affected by flat fading [1], due to that at certain condition the existence of sub channels may be good or extremely bad. The packets which are transmitted through these faded sub channels are highly prone to be lost at the receiver due to non-acceptable errors [2]. OFDM system provides an opportunity to exploit the diversity in frequency domain by providing many subcarriers considered as multiple channels for applications having multiple bit streams [3]. In recent years, for still image transmission, most common way is progressive (or layered) encoding technique.

Dnyaneshwar.K, Electronics and Communications Department, VBIT College, Hyderabad, India.
CH.Suneetha, Electronics and Communications Department, VBIT College, Hyderabad, India.

State-of-the-art image or video compression techniques, such as JPEG2000 [4] (which uses Discrete Wavelet Transform DWT), layered coding is performed. In this technique has loss-less transmission system, in the event of errors reconstruction of image can be stalled due to retransmission of lost coefficients, which is not acceptable in real time content delivery applications.

The wavelet transform [5] has a good localization property in the time domain and frequency domain, can analyze the details of any scale and frequency. Commonly it is used for image compression and image processing. SPIHT "Set Partitioning in Hierarchical Trees"[6]. In this method, more (wide-sense) zero trees are efficiently found and represented by separating the tree root from the tree, so making compression more efficient. In this paper, focus on the point such as, it propose a simple and effective method (SPIHT) combined with Huffman encoding for further compression. A large number of experimental results are shown that this method saves a lot of bits in transmission, further enhanced the compression performance.

2. Proposed Method

It is simple and effective method to save a lot of bits in transmission, it reduce the system energy consumption and provide better image quality at the receiver's end. The block diagram of proposed method is shown in figure 1.

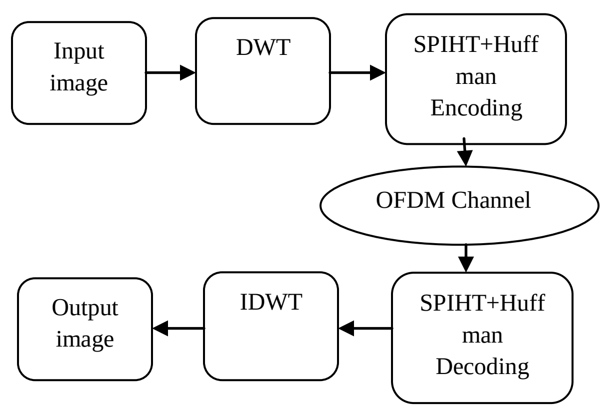


Figure 1:Block Diagram of Proposed Method

A) DWT Process:

To apply HWT on images, we first apply a one level Haar Wavelet to each row and Secondly to each column of the resulting 'image' of the first operation. The resulting image is decomposed into four sub bands: LL, HL, LH and HH sub bands. (L= Low, H=High).The LL-sub band contains an approximation of the original image while the other sub band contain the missing details. The LL-sub band output from any stage can be decomposed further. The decomposition of the DWT image as shown in figure 2.

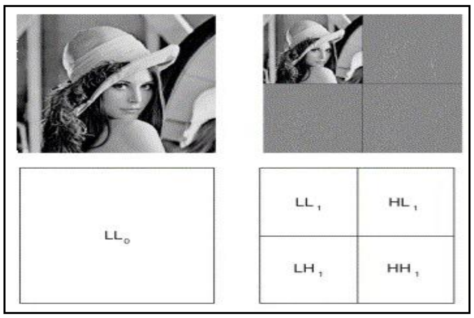


Figure 2: DWT Processed image

B) SPIHT Algorithm:

Description of the Algorithm

SPIHT is an embedded coding technique. In embedded coding algorithms, encoding of the same signal at lower bit rate is embedded at the beginning of the bit stream for the target bit rate. Effectively, bits are ordered in importance. This is especially useful for progressive transmission using an embedded code, where an encoder can terminate the encoding process at any point. SPIHT algorithm is based on following concepts:

1. Ordered bit plane progressive transmission.
2. Set partitioning sorting algorithm.
3. Spatial orientation trees H.

Image data through the wavelet decomposition, the coefficient of the distribution turn into a tree. Wavelet decomposition of the spatial orientation trees structure are shown in Figure3.We can see that each coefficient has four children except the 'red' marked coefficients in the LL sub band and the coefficients in the highest sub bands (HL1;LH1; HH1).

The following set of coordinates of coefficients is used to represent set partitioning method in SPIHT algorithm.The location of coefficient is denoted by(i,j),where i and j indicate row and column indices, respectively.

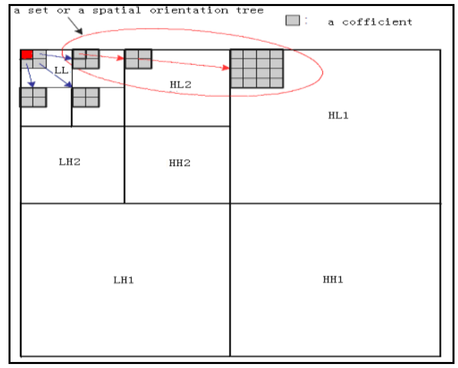


Figure 3: Wavelet decomposition and spatial orientation tree

H: Roots of the all spatial orientation trees,
O(i, j) : Set of offspring of the co-efficient (i, j),
D (i, j): Set of all descendants of the co-efficient (i, j),
L (i, j): D (i, j) -O (i, j).

A significance function *Sn* (τ) which decides the significance of the set of coordinates, τ , with respect to the threshold 2n is defined by:

$$S_n(\tau) = \begin{cases} 1, \text{if } \max_{(i,j)\in\tau}\{|C_{i,j}|\} \geq 2^n \\ 0, \text{else} \end{cases} \quad \ldots\ldots\ldots..(1)$$

SPIHT keeps three lists: LIP, LSP, and LIS. LIP stores insignificant pixels, LSP stores significant pixels and LIS stores insignificant sets. At the beginning, LSP is empty, LIP keeps all coefficients in the lowest sub band, and LIS keeps all tree roots which are at the lowest sub band.

Algorithm: SPIHT

1) Initialization:

1. output n=[$\log_2$max {| ($c_{i,j}$)|}]
2. set LSP =∅ ;
3. set LIP = (i, j) ∈H;
4. set LIS = (i, j) ∈H, where D(i, j) ≠ ∅ and set each entry in LIS as type A;

2) Sorting Pass:

1. for each (i, j) ∈LIP do:
(a) output $S_n(i,j)$
(b) if $S_n(i,j)$ = 1 then move (i, j) to LSP and output sign ($c_{i,j}$)
2. for each (i, j) ∈LIS do:
(a) if (i, j) is type A then
i. output $S_n(D(i, j))$
ii. if $S_n(D(i,j))$ = 1 then

A. for each (k, *l*) ∈O(i, j)
. output $S_n(k,l)$
. if $S_n(k, l)$ = 1 then append (k, l) to LSP, output sign($c_{k,l}$),and $c_{k,l} = c_{k,l} - 2^n \text{sign}(c_{k,l})$
. else append (k, *l*) to LIP

B. move (i, j) to the end of LIS as type B
(b) if (i, j) is type B then
i. output Sn(L(i, j))
ii. ifSn(L(i, j)) = 1 then
. append each (k, l) ∈O(i, j) to the end of LIS as type A
. remove (i, j)from LSP

3) Refinement Pass:

1.for each (i, j) in LSP, except those included in the last sorting pass
.output the n-th MSB of $|c_{i,j}|$

4) Quantization Pass:

1. Decrement n by 1
2. go to step 2)

SPIHT starts coding by running two passes. The first pass is the sorting pass. It first browses the LIP and moves all significant coefficients to LSP and outputs its sign. Then it browses LIS executing the significance information and following the partitioning sorting algorithms.

The second pass is the refining pass. It browses the coefficients in LSP and outputs a single bit alone based on the current threshold. After the two passes are finished, the threshold is divided by 2 and the encoder executes the two passes again. This procedure is recursively applied until the number of output bits reaches the desired number.

Analyses of SPIHT Algorithm

Here a concrete example to analyze the output binary stream of SPIHT encoding. The following is3-level wavelet decomposition coefficients of SPIHT encoding which is shown in figure 4.

	0	1	2	3	4	5	6	7
0	63	−34	49	10	7	13	−12	7
1	−31	23	14	−13	3	4	6	−1
2	15	14	3	−12	5	−7	3	9
3	−9	−7	−14	8	4	−2	3	2
4	−5	9	−1	47	4	6	−2	2
5	3	0	−3	2	3	−2	0	4
6	2	−3	6	−4	3	6	3	6
7	5	11	5	6	0	3	−4	4

Figure 4: wavelet decomposition coefficients of SPIHT

C) Huffman Process:

Huffman's procedure creates the optimal code for a set of symbols and probabilities where each symbol is coded one at a time. A set of symbols and their probabilities are ordered from top to bottom in terms of decreasing probability values. To form the first source prediction, the bottom two probabilities (0.04 and 0.06) are combined to form a "compound symbol" with probability of 0.1,as shown in below table 1.This compound symbol and its associated probability are placed in the first source prediction column so that probabilities of the reduced source also are ordered from the most to the least probable. This process is repeated until a reduced source with two symbols is reached. The second step is to code each reduced source, starting with the smallest source and working back to the original source.

Table 1: Huffman Code Assignment Procedure

Original source			Source reduction			
Symbol	Probability	Code	1	2	3	4
a_2	0.4	1	0.4 1	0.4 1	0.4 1	0.6 0
a_6	0.3	00	0.3 00	0.3 00	0.3 00	0.4 1
a_1	0.1	011	0.1 011	0.2 010	0.3 01	
a_4	0.1	0100	0.1 0100	0.1 011		
a_3	0.06	01010	0.1 0101			
a_5	0.04	01011				

The minimum length binary codes for a two symbol source are symbols 0 and 1. These code symbols are assigned to the two symbols on the right.

The assignment of "1" and "0" is arbitrary and can be reversed without any harm. Since the reduced source symbol with probability 0.6 was generated by combining two symbols in the reduced source to its left, the "0" used to code it, is now assigned to both of these symbols, and "0" and "1" are arbitrarily appended to each to distinguish them from each other. This procedure is repeated for each reduced source until the original source is reached. The final code appears as shown. Average code length which is calculated as follows:

$$Lavg = \sum_{i=0}^{6} P(i) Li \quad \ldots\ldots\ldots\ldots (2)$$

Where p is the probability of symbols appeared ,Li is the length of word code. The average code length is: L_{avg}= (0.4)(1) + (0.3)(2) + (0.1)(3) + (0.1)(4) + (0.06)(5) + (0.04)(5) = 2.2 bits/symbol. And the entropy of the source is 2.14 bits/symbol. The resulting Huffman code efficiency is2.14/2.2 = 0.973. Entropy,

$$H = \sum_{j=1}^{6} p(a_j) \log p(a_j) \quad \ldots\ldots\ldots\ldots (3)$$

D) OFDM Channel:

Orthogonal frequency division multiplexing is a digital modulation method. In digital modulation the signal is split into many narrow band channels. And they have different frequencies. Orthogonal frequency division multiplexing is special type of multi carrier modulation method. Orthogonal frequency division multiplexing is suitable for dispersive channel transmission.

Each carrier is modulated with digital data. Using many carriers with error correction techniques improves the reliability of the communication link. If a few of the carriers get damaged, the link still works. A MIMO wireless system consists of N transmit antennas and M receive antennas which is shown in figure 5. However, unlike phased array systems where a single information stream, say x(t), is transmitted on all transmitters and then received at the receiver antennas. MIMO systems transmit different information streams, say x(t), y(t), z(t), on each transmit antenna. These are independent information streams being sent simultaneously and in the same frequency band. At first glance, one might say that the transmitted signals interfere with one another. In reality, however, the signal arriving at each receiver antenna will be a linear combination of the N transmitted signals.

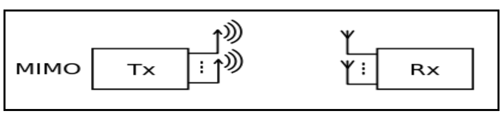


Figure 5: MIMO Process

3. Result Analysis

The experimental results are shown for three different grayscale images with different compression techniques. For this performance analysis we have considered three parameters that is Compression Ratio, Peak Signal to Noise Ratio and Mean Square Error one by one are calculated below.

$$\mathrm{MSE} = \frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}[I(x,y) - I'(x,y)]^2 \ldots (4)$$

Here, I(x, y) = Original image.
I'(x, y) = Output compressed image.
MXN= rows and columns matrix of an image.

$$\mathrm{PSNR} = 10\log 10\left(\frac{255\times 255}{\mathrm{MSE}}\right) \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

CR = (Number of bits in the original image) / (Number of bits in the compressed image)

The results of Lena decompressed images for three methods are shown below in figure 6.

(a)Lena Image

(b) DWT+Huffman

(c) DWT+SPIHT

(d) Proposed method

Figure 6: Decompressed Lena Images for three methods

The resultant Cameraman decompressed images for three methods are shown below in figure 7.

(a)Cameraman Image

(b) DWT+Huffman

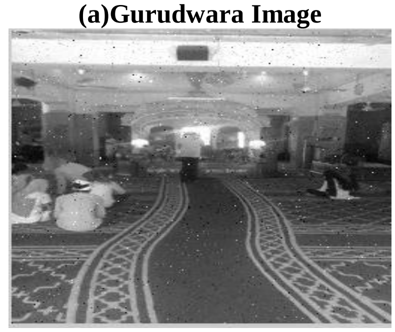
(c) DWT+SPIHT

(d) Proposed method

Figure 7: Decompressed Cameraman Images for three methods

The resultant Gurudwara decompressed images for three methods are shown in figure 8.

(a)Gurudwara Image



(b) DWT+Huffman

(c) DWT+SPIHT

(d) Proposed method

Figure 8: Decompressed Gurudwara Images for three methods

By using the above formulae in the proposed method the following parameters are calculated for three different images, and given in the following tables.

Table 2: Result analysis for Lena 128×128 image

Lena image	CR	MSE	PSNR
DWT+HUFFMAN	0.7392	8.9064	38.6338
DWT+SPIHT	1.1382	2.3866	44.3539
DWT+HUFFAN+SPIHT	1.3747	0.99957	48.1327

Table 3: Result analysis for Cameraman 128×128 image

Cameraman image	CR	MSE	PSNR
DWT+HUFFMAN	0.7427	8.3430	38.9176
DWT+SPIHT	1.1395	2.1417	44.8231
DWT+HUFFAN+SPIHT	1.4566	0.9308	48.442

Table 4: Result analysis for Gurudwara 128×128 image

Gurudwara image	CR	MSE	PSNR
DWT+HUFFMAN	0.7397	9.6012	38.3076
DWT+SPIHT	1.1401	2.4756	44.1940
DWT+HUFFAN+SPIHT	1.2462	0.8511	48.8308

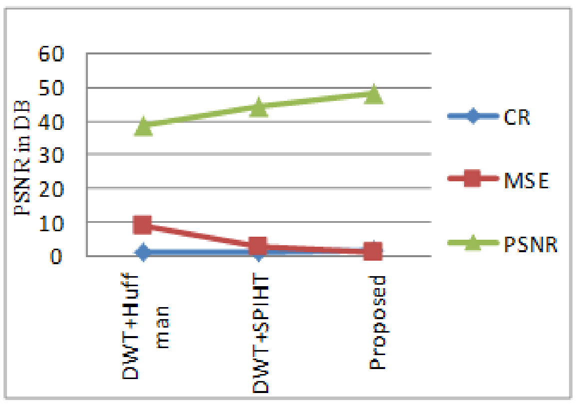


Figure 9: Comparison graph for three Algorithms

4. Conclusion

The SPIHT algorithm with Huffman encoding is simple and effective method for image compression and transmission purpose on OFDM channels. It saves a lot of bits and improves the quality of image. The proposed method shows better performance than DWT+SPIHT and DWT+Huffman alone. It shows the observations of good image quality in terms of PSNR and Compression Ratio (CR) are validated by extensive MATLAB.

5. Scope of the Future Work

In future this work may extend for video compression with existing better algorithms and techniques for image compression.

References

[1] Richard Van inheritable and Ramjee Prasad, "OFDM for wireless multimedia system communications," Arech House Beantown, London, 2000.

[2] R. J. McEliece and W. E. Stark, "Channels with block interference"IEEE Trans. info. Theory, vol. 30, no. 1, pp. 44–53, Jan. 1984.

[3] R. Knopp and P. A. Humblet, "On coding for block fading channels," *IEEE Trans. info. Theory*, vol. 46, no. 1, pp. 189–205, Jan. 2000.

[4] C. Christopoulos, A. Skodras, and T. Ebrahimi, "The JPEG2000 still image coding system: An overview," IEEE Trans. Consumer Electron., vol. 46, no. 4, pp. 1103–127, Nov. 2000.

[5] Marc ANTONINI Michel BARLAUD Pierre MATHIEU et al. "Image coding using wavelet transform" [J]. IEEE Transaction on Image Processing 1992 1(2) 205-220.

[6] Amir SAID William A.PEARLMAN. "A new fast and efficient image codec based on set partitioning in hierarchical trees" [J]. IEEE Transactions on Circuits and Systems for Video Technology 1996 6(3) 243-250.

Dnyaneshwar.K is Pursuing his M.Tech in Communication Systems in VBIT College, Hyderabad, and Qualified B.E in Telecommunication Engineering from Basavakalyan Engineering College in 2009. His areas of interest in Digital Image Processing, MATLAB, Wireless mobile communication.

Ch.Suneetha received an M.Tech degree in Electronics & Communication Engineering from JNTU Hyderabad, and qualified a B.E degree from Chaitanya Bharathi Institute of Technology in 2001. She currently works as Associate professor in VBIT, Hyderabad, India. Her areas of interest in signal processing, MIMO, Wireless mobile communication and High speed digital communication.