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Performance Evaluation of SPIHT Using CDF9/7 Wavelet Along With Huffman Coding for Lossy Image Compression

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ABSTRACT: Image Data Compression is a science that is concerned with the reduction of the number of bits required to store, transmit and reconstruct images without loss of any information. Though various transforms are used in the field of image compression, wavelets are most popular, and are increasingly being applied in the field of digital image processing. A fundamental shift in the image compression approach came after the Discrete Wavelet Transform (DWT) became popular. After DWT was introduced, several codec algorithms were proposed to compress the transform coefficients as much as possible. Among them, Embedded Zero tree Wavelet (EZW), Set Partitioning into Hierarchical Trees (SPIHT) and Embedded Block Coding with Optimized Truncation (EBCOT) are the most famous ones. To overcome the inefficiencies in the JPEG standard and serve emerging areas of mobile and Internet communications, the new JPEG2000 standard has been developed based on the principles of CDF9/7 wavelet in DWT.
In this paper CDF9/7 and Bior4.4 wavelets are applied with SPIHT (Set Partitioning in Hierarchal Trees) on a lossy image compression and performance is evaluated in terms of performance metrics PSNR and MSE. Further study of SPIHT using wavelet CDF9/7 along with Huffman Coding on gray-scale or monochrome images is done. Simulation results show that SPIHT using CDF9/7 wavelet along with Huffman Coding gives better image quality and compression ratio than traditional SPIHT.

KEYWORDS: Discrete Wavelet Transform (DWT), Embedded Zero tree Wavelet (EZW), Embedded Block Coding with Optimized Truncation (EBCOT), Set Partitioning in Hierarchal Trees(SPIHT).

I.INTRODUCTION

The image compression can be termed as a technique to reduce the size of the image with no significant loss in the image quality. With the digitalization entering into the field of image sampling a image is used in more fields like photography, medical imaging (DICOM) satellite imaging etc. using a uncompressed required a large storage space, transmission time and band width as well. Despite the rapid growth in data storage capacity, processor speed, digital communication system performance, storage and transmission of images still pose a considerable challenge. The process of image compression can be loss less or lossy. Depending on the application the type of compression can be used.

II. SYSTEM MODEL AND ASSUMPTIONS

A. IMAGE COMPRESSION PROCESS:

A typical lossy image compression system consists of source Encoder, Quantizer and Entropy Encoder. The compression is accomplished by applying a linear transform to decorrelate the Image and then quantization followed by entropy coding of the quantized value which is shown in figure 1.

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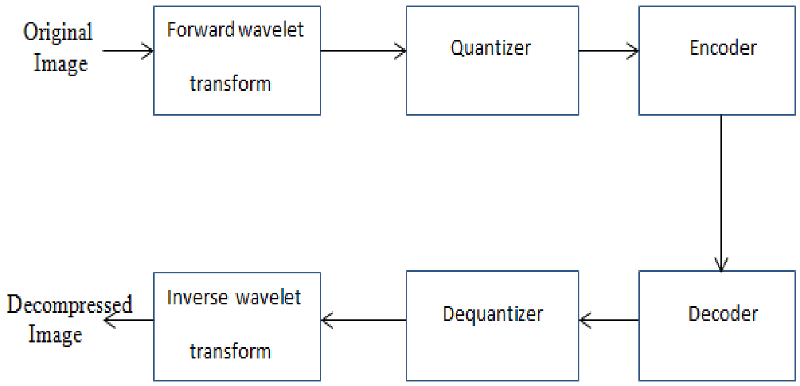
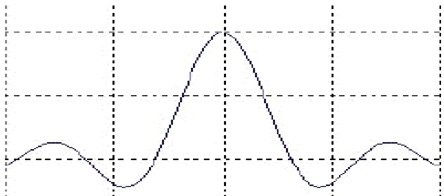


Figure1: Image compression process

Our aim is to evaluate the performance of the SPIHT (Set Partitioning In Hierarchal Trees) using CDF9/7 wavelet for smooth images compression and further improve the compression ratio by using Huffman Encoder with SPIHT.
CDF9/7 wavelet function gives floating point filter coefficients and due to this floating point nature of filter it gives lossy compression with SPIHT but due to higher energy compaction with fewer wavelet coefficients it results in higher compression ratio. Also output of the SPIHT is embedded bit stream and this bit stream is reduced by using Huffman Encoder with SPIHT.

B.WAVELET TRANSFORM:
Wavelet analysis represents the next logical step: a windowing technique with variable-sized regions. Wavelet analysis allows the use of long time intervals where more precise low frequency information is required and shorter regions where high-frequency information.



Mathematically, the process of Fourier analysis is represented by the Fourier transform:

C.CDF9/7 WAVELETS
Cohen-Daubechies-Feauveau wavelet of LPF whose length is 9 and 7(i.e. CDF 9/7) which are the popular wavelets for a wavelet based image compression .The biorthogonal CDF 9/7 wavelet is a more complex wavelet than the CDF 5/3 wavelet. The CDF 9/7 analysis and synthesis wavelets has two sets of scaling and wavelet functions for analysis and synthesis, as they are identical so more orthonormal than the CDF 5/3. The CDF9/9 has high compression ration then CDF 5/3 due to high energy compaction of CDF 9/7, thus it also give high image quality. Now, the scaling function and the wavelet function and dual basis of the CDF9/7 is represented in figure2.

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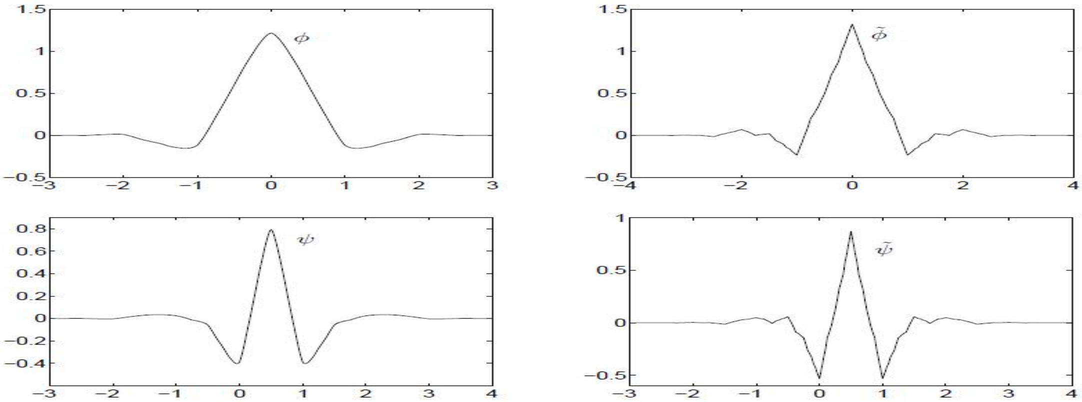

Figure 2: Cohen-Daubechies-Feauveau 9/7 scaling and wavelet functions

Performance of SPIHT algorithm using CDF9/7 wavelet is computed in terms of PSNR value for different types of smooth images. Only performance metric PSNR is computed for lossy image compression at different levels of decomposition.

In this paper we are further extending the work by approaching SPIHT algorithm using CDF9/7 wavelet with Huffman encoder. This new scheme is applied on smooth images like (Lena, Barbara, Pepper). These type of images have slow change in gray level values and high redundant data. Due to higher energy compaction of CDF9/7 wavelet, it gives higher compression ratio. Compression efficiency of SPIHT can be improved further by using Huffman encoder without degrading the image quality as Huffman encoder gives lossless compression.

D.SPIHT

A wavelet-based still image coding algorithm known as set partitioning in hierarchical trees (SPIHT) it is developed so that it generates a continuously scalable bit stream, so that a single encoded bit stream can be used to produce images at various bit-rates and quality, without any drop in compression.

Using the SPIHT algorithm, the image is first decomposed into a number of sub bands using hierarchical wavelet (Bior4.4) decomposition. The sub bands obtained for two-level decomposition are shown in figure 3.

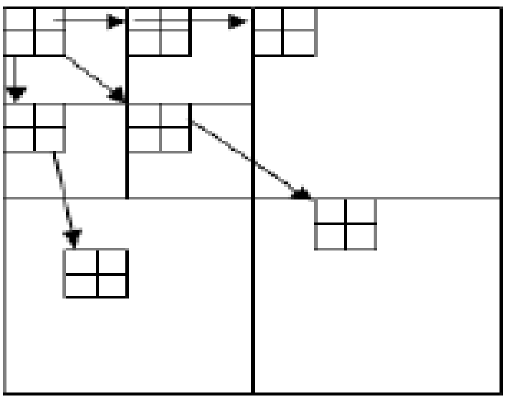

Figure 3:Quad tree organization of wavelet coefficients in SPIHT

The real implementation of SPIHT is illustrated below. To make it simple, the following sets of coordinates are defined.

(1) O(i, j): set of coordinates of all offspring of node (i, j);

(2) D(i, j): set of coordinates of all descendants of the node (i, j);

(3) H: set of coordinates of all spatial orientation tree roots (nodes in the highest pyramid level);

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(4) L(i, j)=D(i, j)-O(i, j).
Thus, except at the highest and lowest levels, we have
O(i, j)=(2i, 2j), (2i, 2j+1), (2i+1, 2j), (2i+1, 2j+1).

Define the following function.

Denotes the significance of a set of coordinates, where the preset significant threshold used in the nth stage is denoted by T (n). The SPIHT coding algorithm is described as follows.
First, T (0) is assumed to be 2^{M-1}. Here M is chosen such that the largest coefficient magnitude c_{max}, satisfies
$2^{M-1} \leq c_{max} < 2^{M}$. In the coefficient magnitude, the encoding is progressive to successfully use a sequence of thresholds $T(n)=2^{(M-1)-n}$, n=0,1,2,...M-1. These thresholds are of the power of '2', so that the encoding can be taken as the bit plane encoding of the wavelet coefficients. All the coefficients with the magnitudes between T(n) and 2T(n), at stage n are significant and their positions and the sign bits are encoded. This is called sorting pass process. Then each coefficient with the magnitude at least 2T(n) is refined by encoding the 'n'th most significant bit. This is known as refinement pass.

E. HUFFMAN CODING

From Shannon's Source Coding Theory, it is known that the source can be coded with an average code length that is close to the entropy of the source. But by Huffman coding technique is used to produce a shortest possible average code length for the given source symbol set and the associated probability of occurrence of the symbols. Codes generated using these coding techniques are popularly known as Huffman codes. Huffman coding technique is based on the following two observations regarding optimum prefix codes.

- The more frequently occurring symbols can be allocated with shorter code words than the less frequently occurring symbols.
- The two least frequently occurring symbols will have codeword of the same length, and they differ only in the least significant bit.

Average length of these codes lies close to entropy of the source. The Huffman coding is an entropy encoding algorithm mainly used for lossless data compression.
The prefix code of each symbol is obtained by choosing special symbols for the representations, so a shorter string of bits are obtained which are used for less common source symbols.

F. SPIHT USING CDF9/7 WAVELET WITH HUFFMAN CODING:

The DWT, wavelet filter are used to decompose the image into different sub band. Now we will be considering the decomposition level 5as it gives a best result. The CDF9/7 wavelet is the second generation wavelet which is used present international standard JPEG 2000. Which has 9 filter-taps for the analysis filter and 7 filter-taps for the synthesis filter? As the filer's coefficient is floating point in nature results in lossy compression But due to higher energy compaction of image with fewer significant wavelet coefficients it gives higher compression ratio.
Also CDF9/7 wavelet function is symmetrical than Bior4.4 wavelet function that results in better image quality. Output of the DWT, sub bands are used by the SPIHT algorithm by partitioning the sets into three lists by making hierarchical trees as discussed above.
Output of the SPIHT is an embedded bit stream which can be further compressed using entropy encoders. Two popular entropy encoders, Arithmetic and Huffman encoder are used with many lossy compression Standards.
Huffman encoder is used in Current lossy compression standard JPEG which gives the highest compression ratios than other existing techniques with acceptable image quality. Also Significance mapping of SPIHT is such that Arithmetic coding provides very little gain to the compression ratio
Experimentally it has been observed that output of SPIHT has large number of seriate "0" situation and '000' appears with the highest probability. So to best exploit this situation we used the Huffman encoder as variable length coding because of its simplicity and fast execution.
The procedure is as follows:

- First divide the output bit stream into 3 bits as a group like 111 000 111 000 100 000 010 000………. 100 00. In this process, there may remain 0, 1, 2 bits which don't participate. So header of the output bit stream of Huffman encoder has two bits to record the number of bits which do not participate in group and that remainder bits are directly added to output in end.

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- Now we have 8 different symbols from 000 to 111.We found the probability of each distinct symbol in long output bit stream of SPIHT.
- After computing the statistical probabilities of each distinct symbol we applied Huffman encoder to best exploit the probabilities of the symbols as it assigns the less numbers of bits to the symbols has high probability of occurrence.
- At the output of the Huffman encoder we have less number of bits as compared to the output bit stream of the SPIHT. Thus Huffman encoder improves the compression ratio of SPIHT compression.
- Decoding is the reverse process of encoding. Huffman coding does not degrade the quality of the reconstructed image as it provides lossless compression.

in a minimum level. This eventually enables CR-Networks nodes to determine optimum path nodes and channels for an efficient communication in CR-Networks. The CR technology allows Secondary Users (SUs) to seek and utilize "spectrum holes" in a time and location-varying radio environment without causing harmful interference to Primary Users (PUs). This opportunistic use of the spectrum leads to new challenges to the varying available spectrum. Using a Trust-Worthy algorithm, it improves the trustworthiness of the Spectrum sensing in CR-Networks.

III. RESULT AND DISCUSSION

The following results are obtained for the smooth image pepper.bmp (512*512) in MATLAB.
The MSE and PSNR values of the SPHIT using the Bior 4.4 and CDF 9/7 wavelet at different bit rate is calculate and tabulated

Bit.rate	MSE		PSNR(Db)	
	Bior4.4+SPIHT	CDF9/7+SPIHT	Bior4.4+SPIHT	CDF9/7+SPIHT
.05	161.75	150.52	26.04	26.35
0.1	88.75	77.49	28.65	29.23
0.2	44.14	39.5	31.68	32.16
0.3	29.76	27.99	33.39	33.65
0.4	23.39	21.58	34.44	34.78
0.5	18.58	18.09	35.44	35.55
0.6	16.48	16.11	35.96	36.58
0.7	14.78	14.28	36.43	36.59
0.8	13.51	12.73	36.83	37.49
0.9	12.3	11.56	37.23	37.5
1.0	10.76	10.48	37.81	37.92

For a better compression technique MSE value should be as low as possible and PSNR value should be high for a good image quality.
From the table we observe that CDF 9/7 wavelet that the SPHIT algorithm gives lower MSE value and slightly higher PSNR value when compared to that of SPHIT with Bior(4.4) wavelet. Upto bitrate 0.5, CDF 9/7 gives much improved performance when compared to Bior (4.4)

From the table we observed that CDF9/7 wavelet with SPIHT algorithm gives lower MSE values and slightly higher values of PSNR as compared to the SPIHT with Bior4.4 wavelet.Upto bitrate 0.5, CDF9/7 gives much improved performance as compared to Bior4.4

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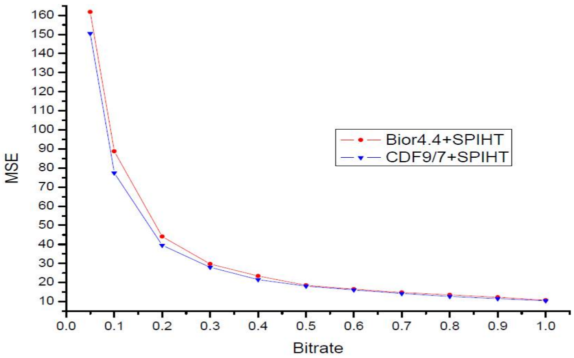
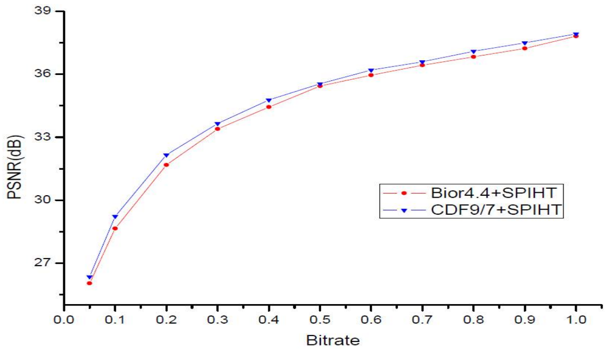


The graph shows MSE Vs Bitrate



The graph shows PSNR Vs Bitrate

Original image pepper with PSNR= 31.68 at bitrate 0.2

Reconstructed image using Bior4.4+SPIHT

Reconstructed image using CDF9/7+SPIHT PSNR= 32.16at bitrate 0.2

From the above figures we can see that CDF9/7wavelet with SPIHT gives better image quality of reconstructed image at low bitrate (high compression ratio) as compared to Bior4.4 with SPIHT. Reconstructed image by Bior4.4 wavelet is little blurred while image reconstructed by CDF9/7 is smooth.

Compression Ratio comparison of Traditional SPIHT and SPIHT using CDF9/7 wavelet with Huffman encoder

Bitrate	Traditional SPIHT	CDF9/7+SPIHT with Huffman Coding
0.05	160	166.75
0.1	80	84.15
0.2	39.99	42.13
0.3	26.66	27.88
0.4	20	20.77
0.5	16	16.73
0.6	13.33	13.86
0.7	10.66	11.06
0.8	10	10.37
0.9	8.88	9.21
1.0	7.99	8.27

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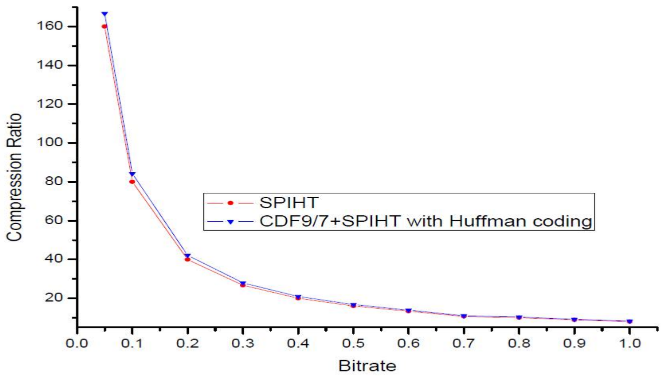
The table shows the comparison between tradition SPIHT and SPIHT with Huffman encoder. From the table we can see that SPIHT using CDF9/7 wavelet along with Huffman encoder gives better compression ratio than original SPIHT. Low bitrates results in high compression ratio but poor image quality.CDF9/7 provides higher energy compaction with fewer wavelet coefficients those results in high compression ratio and Huffman encoder further improves the compression efficiency of SPIHT compression scheme without degrading the image quality.

Finally we obtain the graphical representation where we can see that compression ratio of SPIHT using CDF9/7 wavelet along with Huffman encoder gives is higher than the original SPIHT. Graph shows that as we increase the bitrate above 0.6, compression ratio decreases and not much improvement over traditional SPIHT by the new one. But at low bitrate SPIHT using CDF9/7 wavelet along with Huffman encoder gives significantly improved results with acceptable image quality as shown before in subjective evaluation.



The graph shows Compression ratio Vs Bitrate

IV.CONCLUSION

In this paper we have discussed SPIHT algorithm with Bior4.4 wavelet and CDF9/7 wavelet. Wavelets provide the platform to analyze the image at different resolution by multiresolution analysis property of the wavelet. CDF9/7 wavelet gives floating point filter coefficients that results in lossy compression but it also provides higher energy compaction with fewer coefficient that gives better compression ratio.

Performance of SPIHT is evaluated in terms of MSE (Mean Squared Error), PSNR (Peak Signal to Noise Ratio) and Compression Ratio for smooth gray scale images.

After analyzing the various evaluated results and graphs, we have concluded:

- SPIHT using CDF9/7 wavelet gives better Image quality of reconstructed image as compared to traditional SPIHT that uses Bior4.4 wavelet. Below bitrate 0.05 image quality is not acceptable for both wavelets but as we increase the bitrate image quality increases significantly.
- SPIHT using CDF9/7 wavelet along with Huffman encoder as entropy encoder gives better compression ratio over traditional SPIHT. By using Huffman encoder lot of bits can be saved in image data transmission.CDF9/7 wavelet and Huffman encoder both contribute to improve the compression ratio of SPIHT. Huffman encoder gives lossless compression, it does not degrade the image quality and reduces the system complexity.

REFERENCES

[1] N. Johnston, and R. Safranek, "Signal compression based on models of human perception,"*Signal Processing, IEEE*, vol. 81, pp.1385–1422, Oct.1993.

[2] Sonja Grgic,MilsavGrgic and BrankaZovko, "Performance analysis of image compressionusing wavelets" IEEE Transactions, vol. 48, No. 3, June 2001.

[3]Ho Weng Leong,UmiKalthumNgah, P.A.Venkatachalam, Noor Eliza Abd.Khalid, "ImageCompression Software Analysis and Design," Proceedings ROVPIA 1999. pp.385-392, Malaysia,16-18 July 1999.

[4]RafaelC.Gonzalez, Richard E. Woods, Steven 3rd Edition, "Digital Image Processing UsingMATLAB," Prentice-Hall, 2004.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

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(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 2, February 2016

[5] K. Sayood, *Introduction to Data Compression*, Second edition, Academic Press, 2000.
[6] *EBCOT: Embedded Block Coding with Optimized Truncation*, ISO/IEC JTC1/SC29/WG1N1020R, Oct. 1998.
[7] B. Yan, H. Zhang, "SPIHT Algorithm and its Improvement," Computer Applications andSoftware, vol. 25(8), pp.245-247, 2008.
[8] COHEN, DAUBECHIES, FEAUVEAU, "*Biorthogonal Bases of Compactly Supported Wavelets*". Comm. Pure and Applied Mathematics, vol. 45, 1992, pp. 485-560.
[9] A.S. Lewis and G. Knowles, "Image Compression using 2-D Wavelet Transform", IEEETransactions on Image Processing, 1(2):244-250, April 1992.
[10] J.M. Shapiro, "Embedded image coding using zerotrees of wavelet coefficients", IEEETransactions on Signal Processing, 41:3445-3462, Dec,1993.
[11] H. L. Xu, S. H. Zhong, "Image Compression Algorithm of SPIHT Based on Block-Tree,"Journal of Hunan Institute of Engineering, vol. 19(1), pp.58-61, 2009.
[12] R. D. Dony and S. Haykin, "Neutral network approaches to image Compression,"Proceedings of the IEEE, vol.83, No.2, 2005.