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Image Compression Using New Wavelet Bi-Orthogonal Filter Coefficients by SPIHT algorithm

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ABSTRACT: *In recent years there has been a tremendous increase in the usage of computers for a variety of tasks. With the advent of digital cameras, one of the most common uses has been the storage, manipulation, and transfer of digital images. The files that comprise these images, however, it can be quite large and can quickly take up precious memory space on the computer's hard drive. In multimedia application, most of the images are in color. And color images contain lot of data redundancy and require a large amount of storage space. In thispaper new wavelet bi-orthogonal filter coefficients for wavelet decomposition and reconstruction of image are introduced for better compression of color images, when the image is compressed by using these filter coefficient in DWT-SPIHT schema then it perform better than DWT-SPIHT schema with wavelet 9/7 filter. The compression result by using these filter coefficient will be compared with PSNR and MSE parameters.*

KEYWORDS: *Image Compression, wavelet Transform, Image texture, wavelet 9/7 filter, SPIHT Algorithm.*

I. INTRODUCTION

With advances in multimedia technologies, demand for transmission and storage of voluminous multimedia data has dramatically increased and, as a consequence, data compression is now essential in reducing the amount of data prior storage or transmission. Compression techniques aim to minimise the number of bits required to represent image data while maintaining an acceptable visual quality. Image compression is achieved by exploiting the spatial and perceptual redundancies present in image data.

Since last two decade the discrete wavelet transform (DWT) has witnessed great success for image compression. One of the best image compression techniques is using wavelet transform. It is comparatively new and has many advantages over others. The wavelet transform has become a useful computational tool for a variety of signal and image processing applications. For example, the wavelet transform is useful for the compression of digital image files, smaller files are important for storing images using less memory and for transmitting images faster and more reliably.

The discrete wavelet transform (DWT) refers to wavelet transforms for which the wavelets are discretely sampled. Most notably, the discrete wavelet transform is used for signal coding, where the properties of the transform are exploited to represent a discrete signal in a more redundant form, often as a preconditioning for data compression. The discrete wavelet transform has a huge number of applications in Science, Engineering, Mathematics and Computer Science.

Wavelettransforms have become one of the basic tools of signal processing, image processing, and numericalcomputation. In particular, biorthogonal symmetric wavelets manifested remarkable abilities in still image compression. So-called 9/7 wavelets [1] were adopted by the JPEG 2000 image compression standard. In this paper, we present a new family of biorthogonal wavelet transforms, which are proven to be efficient for image compression.The 9/7 wavelet filters for conventional two-channel filter banks, upon the first application in image compression.

This paper introduces new wavelet based bi-orthogonal filter coefficient that can give better result in case PSNR and MSE compared to wavelet 9/7 filter.

This paper is organized as follows: Section-II gives the detailed presentation of 2-D wavelet transform. Section-III gives SPIHT algorithm and proposed filter coefficient Section IV gives Image coding model experimental results. Conclusion and future work is given in section-V.

II. TWO-DIMENTIONAL DWT

In two dimensions DWT, a two-dimensional scaling function (x,y), and three two-dimensional wavelets, $\varphi H(x, y)$, $\varphi V (x, y)$, and $\varphi D(X, y)$, are required. Each is the product of two one-dimensional functions. Excluding products that produce one-dimensional results, like $\varphi(x)(x)$, the four remaining products produce the separable scaling function.

$\Phi(x,y)= \varphi(x)\, \varphi(y)$ (1)

And separable directionally sensitive wavelets

$H(x,y)= (x)\, \varphi(y)$ (2)

$V(x,y)= \varphi(x)\, (y)$ (3)

$D(x,y)= (x)\, (y)$ (4)

These wavelets measure functional variations, intensity variations for image along different directions, H measures variations along columns (for example horizontal edges), V measure variations along rows (likes vertical edges) and D corresponds to variation along diagonals. The direction sensitivity is natural sequence of separability; it does not increase the computational complexity of 2-D transform.

Wavelets are mathematical functions which decompose data into different frequency components, and study each component with a resolution matches to its scale. They have advantages over Fourier methods in analyzing physical situationswhere the signal contains discontinuities and sharp spikes.Wavelets were developed independently in the fields of mathematics, quantum physics, electrical engineering, and seismicgeology. Interchanges between these fields during the last decade have led to many new wavelet applications such as image compression, turbulence, human vision, radar, and earthquake prediction. The wavelet transform [2] is a mathematical tool for the decomposition.

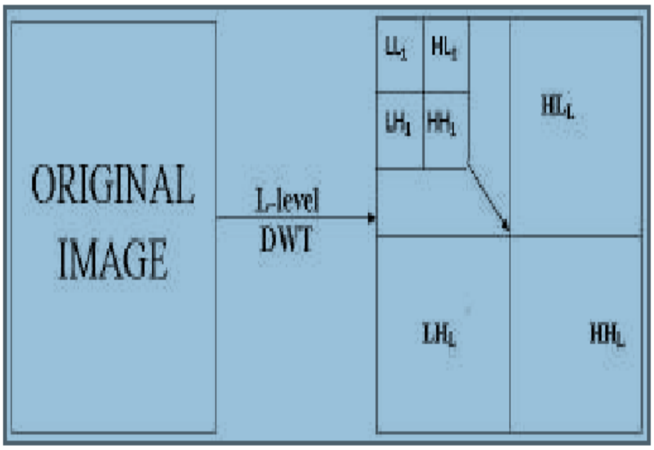

Figure 1: Wavelet Transform

The wavelet transform is identical to a hierarchical sub band filtering system[3], where the sub bands are logarithmically spaced in frequency domain. The basic idea of the DWT for a 2-dimensional image is described as follows. An image is first decomposed into four parts based on frequency sub bands, by critically sub sampling horizontal and vertical channels using sub band filters and they are named as Low-Low (LL), Low-High (LH), High-Low (HL), and High- High (HH) sub bands as shown in figure 1.

To obtain the next scaled wavelet coefficients, the sub band LL is further decomposed and critically sub sampled. This process is repeated several times, which is determined by the application at hand. The block diagram of this process is shown in figure 1. Each level has various bands information such as low–low, low–high, high–low, and high–high frequency bands. Furthermore, from these DWT coefficients, the original image can be reconstructed. This reconstruction process is called the inverse DWT (IDWT). If C[m,n] represents an image, the DWT and IDWT for C[m,n] can similarly be defined by implementing the DWT and IDWT on each dimension and separately.

III. SPIHT ALGORITHM

The SPIHT[4] image coding algorithm was developed bySaid and Pearlman in 1996. SPIHT algorithm is another more efficient implementation of the embedded zerotree wavelet (EZW)[5] algorithm by Shapiro.SPIHT achieves better performance by exploiting the spatial dependencies of the DWT coefficients in different subbands.

The interband spatial dependencies are captured in the form of parent-child relationships,this is illustrated in Figure 2. The arrows shown in Figure 2 point from the parent node to its four children. With the exception of the coarsest subband and the finest subbands, each DWT coefficient (parent) at the ith level of decomposition is spatially correlated to 4 child coefficients at level i-1 in the form of 2×2 block of adjacent pixels. These 4 child coefficients are at the same relative location in the subband decomposition structure.

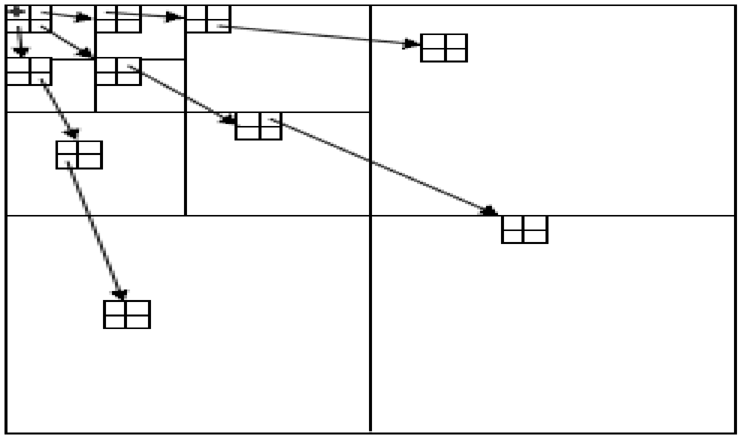

Figure 2: Parent-child relationships for a 3-level wavelet decomposition.

This relationship is utilized during SPIHT quantization: if a parent coefficient is insignificant with respect to a particular threshold, then all of its children would most likely be insignificant and similarly, significant coefficients in the finer subbands most likely correspond to a significant parent in the coarser subband. Thisresults in significant savings: only the parent's position information needs to be coded since the children's coordinates can be inferred from the parent's position information.

SPIHT captures the current bit-plane information of all the DWT coefficients and organizesthem into three ordered lists:

1. List of significant coefficients (LSC).
2. List of insignificant coefficients (LIC).
3. List of insignificant sets of coefficients (LIS).

LSC constitutes the coordinates of all coefficients which are significant. LIS contains the roots of insignificant sets of coefficient. They can be two different types; the first type known as TYPE A has all the descendants insignificant within a given bit-plane, the second type known as TYPE B excludes the four children of the root node. Finally, LIC contains a list of all the coefficients that do not belong to either LIS or LSC and are insignificant. The operation of SPIHT can be grouped into three sequential steps: initialization, sorting pass (SP) and refinement pass (RP) & threshold update.

1) Initialization: The initial threshold is set to 2^log2(max(|Ci,j|), where max(|Ci,j|) is the largest DWT coefficient. The algorithm starts at the coarsest band in the subband pyramid. All the coefficients in the subband are added to the LIC and the coefficients with descendants (tree roots) are added as to LIS as TYPE A. Thus, during initialization, every coefficient is initialized to an insignificant state.
2) Sorting pass: At each threshold level, the LIC is coded first, followed by the entries in LIS. A given entry in LIC is tested and moved to LSC if found significant. The sign bit of the significant coefficient is also immediately coded. The LIS entries are coded quite differently. For a TYPE A LIS entries, if any member in the hierarchical tree is found to be significant, the immediate children are tested and are added to either LIC or LSC. The parent is added to the end of LIS as a TYPE B entry or removed from the LIS if it does not have any grandchildren. For TYPE B entries, if any member in the hierarchical tree is foundto besignificant, the immediate children are removed and added as TYPE A entries to the end of LIS. Processing continues till the end of LIS is reached. SP also records the position of the coefficients that are found significant during thecurrent pass.
3) Refinement pass and threshold update: Refinement pass adds precision to the LSP entries obtained before the current sorting pass by outputting the most significant bit corresponding to the existing threshold. On completion of the refinement, the threshold is halved and the cycle is repeated starting from step 2.
4) The bit rate can be controlled precisely in the SPIHT[4] algorithm because the output produced is in single bits and the algorithm can be terminated at any time. The decoding process follows the encoding exactly and is almost symmetrical in terms of processing time.

The bi-orthogonal 9/7 filter coefficient and the new proposed filter coefficient are shown in table:-

Table-I. Table Contains 9/7 Filter Coefficient and Proposed Filter Coefficient

9/7 Filter Coefficient		**Proposed Filter Coefficient**	
Low Pass Filter	**High Pass Filter**	**Low Pass Filter**	**High Pass Filter**
0	0	-0.0015	0.0015
0.0378	-0.0645	0.0027	0.0027
-0.0238	0.0407	0.0049	-0.0049
-0.1106	0.4181	-0.0128	-0.0128
0.3774	-0.7885	-0.0025	0.0025
0.8527	0.4181	0.0264	0.0264
0.3774	0.0407	-0.0050	0.0050
-0.1106	-0.0645	-0.0455	-0.0455
-0.0238	0	0.0211	-0.0211
0.0378	0	0.0756	0.0756
		-0.0568	0.0568
		-0.1404	-0.1404
		0.1817	-0.1817
		0.6594	0.6594
		0.6594	-0.6594
		0.1817	0.1817
		-0.1404	0.1404
		-0.0568	-0.0568
		0.0756	-0.0756
		0.0211	0.0211
		-0.0455	0.0455
		-0.0050	-0.0050
		0.0264	-0.0264
		-0.0025	-0.0025
		-0.0128	0.0128
		0.0049	0.0049
		0.0027	-0.0027
		-0.0015	-0.0015

After reconstruction of image two parameters are measured as follows:-

However, the wavelet transform yields perfect reconstruction only if its numbers are stored as infinite imprecision numbers. Peak signal-to noise ratio (PSNR) is one of the quantitative measures for image quality evaluation which is based on the mean square error (MSE) of the reconstructed image.

(i) Mean square error (MSE) is a distortion measure for lossy compression. The MSE between two image is given as:-

$$\text{MSE}=\frac{1}{k}\sum_{i=1}^{k}(Pi-Qi)^2$$

And root mean square error is given by:-

$$\text{RMSE}=\sqrt{MSE}$$

Here Pi=Original Image data

Qi= Reconstructed Image Data

K= Size of image

(ii) The peak signal to noise ratio for reconstructed image is given by:-

$$\text{PSNR}= 20\ \text{Log}10\left(\frac{Max(Pi)}{RMSE}\right)$$

IV. MODELING AND RESULTS

Color image compression[6][7] is very important in today's communication era because most of the images are in color. Color images take more space for storage. Also without compression it may take long time for transferring images through internet.

The image compression algorithm for proposed schema has following steps:-

(A) Compression:-

1. Firstly image is converted in digital form and read by respective software (MATLAB (That I am using)).
2. The RGB image is converted into YCbCr format.
3. Separate Y, Cb and Cr components of image.
4. Decompose each component of image by using 2-DWT with proposed filter coefficient scheme.
5. Code the coefficient of each component by using SPIHT coder.

(B) Decompression:-

1. Read the coded image.
2. Decode the coded image by using SPIHT encoder.
3. Pass the decoded image through inverse DWT with proposed filter coefficient.
4. Covert the image from YCbCr to RGB format.
5. Measure MSE and PSNR for an image.
6. Repeat the compression and decompression process by using wavelet 9/7 filter coefficient.
7. Compare the result for both the cases.

The image coding results are compared in this section between DWT-SPIHT with wavelet 9/7 filter coefficient and DWT-SPIHT with proposed filter coefficient. Here SPIHT coding scheme is utilized to organize the compressed bit stream in the compression scheme. The compression ratio is set as the input of the compression system. The experimental results include four different ratio PSNR values for DWT-SPIHT with 9/7 wavelet filter and proposed filter. In Shown figure we see that the proposed filter based DWT-SPIHT schema is better than the old DWT-SPIHT compression schema.

Figure-3 (a) house image (b) Recons-trusted Image at 0.1bpp (c) Reconstructed Image at 0.25 bpp (d) Reconstructed Image at 0.5 bpp

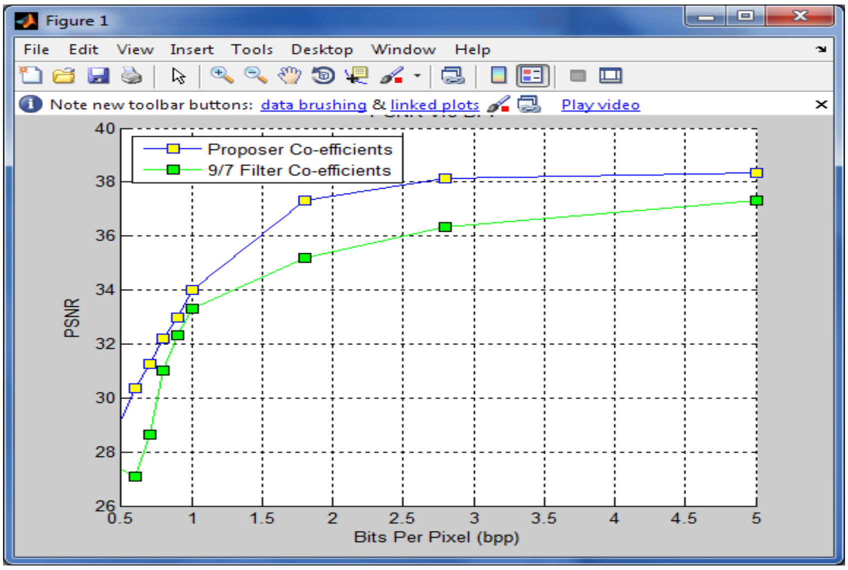

Figure-4. Comparison in PSNR with respect to bpp for Wavelet 9/7 filter based compression and proposed filter based Compression for house image

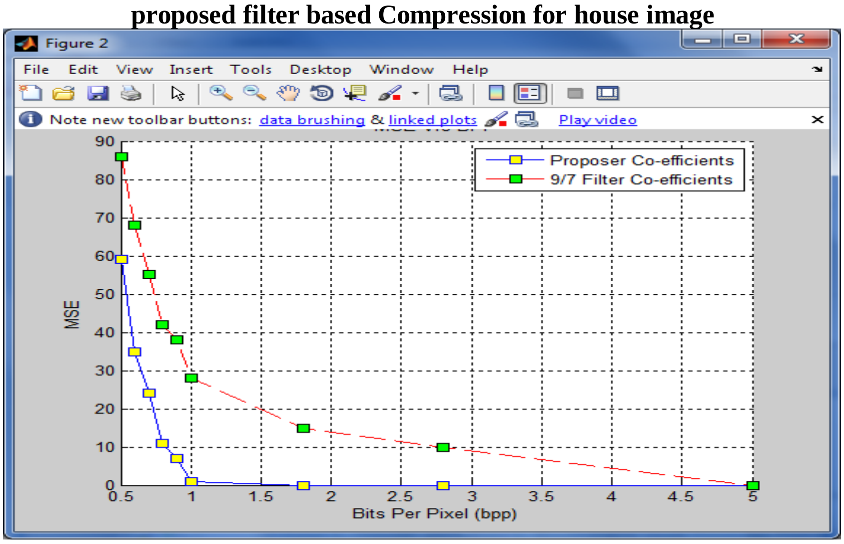

Figure-5 Comparison in MSE with respect to bpp for Wavelet 9/7 filter based compression and proposed filter based Compression for house image

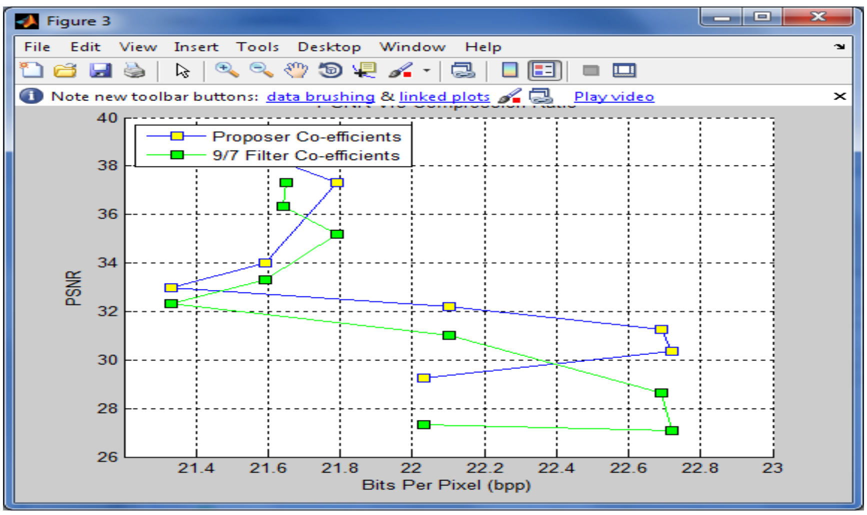

Figure-6 Figure showing Comparison in PSNR with respect to compression ratio for Wavelet 9/7 filter based compression and proposed filter based Compression for house image.

V. CONCLUSION AND FUTURE WORK

Compressing color images efficiently are one of the main problems in multimedia applications. So we have tested the efficiency of color image compression using SPIHT algorithm. The SPIHT algorithm is applied for luminance (Y) and chrominance (Cb,Cr) part of RGB to YCbCr transformed image. Reconstructed image is verified using MSE and PSNR. In this paper we are introducing a new wavelet bi-orthogonal filter coefficients. The proposed filter coefficient with DWT-SPIHT compression scheme performs better than DWT-SPIHT compression scheme with wavelet 9/7 filter.

Our future work includes applying this scheme for wavelet based video coding at low computational complexity.

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