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Squeezing of Color Image Using New Wavelet Bi-Orthogonal Filter Coefficient Based Preliminary Plan

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Abstract:
In this paper, for better image squeezing, the new wavelet bi-orthogonal filter coefficients for wavelet decomposition and reconstruction of image are introduced, when the image is squeezed using these filter coefficient in DWT-SPIHT preliminary plan then it perform better than DWT-SPIHT preliminary plan with wavelet 9/7 filter and wavelet 5/3 filter. These filter coefficient squeezing results show that the image, which is reconstructed, has higher Peak Signal to Noise Ratio(PSNR) and low Mean Square Error(MSE) than wavelet 9/7 filter and wavelet 5/3 filter.

Key words: *Squeezing of Image, wavelet Transform, texture of Image, wavelet 9/7 filter, wavelet 5/3 filter*

1. Introduction

The discrete wavelet transform are used for squeezing the image since 1990. In the 2D-DWT squeezing technique, two one dimension are used for vertical & horizontal direction respectively[1].The image have two types of singularities in which the 2-D discrete wavelet transform(Traditional 2-D DWT) are able to capture point singularities with more effectiveness but at the time of capturing line singularities it becomes failed. It got failed because alignment of horizontal or vertical direction of image and edges & contour in images are not perfect. This imperfectness can be solving by using a new transform by filtering the image in both direction.

If the edges and contours are not aligned vertically and horizontally then according to the property of DWT the energy of image is spread across sub-bands. For removing that condition there is a requirement of directional transform so that energy cannot spread in sub-bands. Attempts on orientation adaptive transform can be classified into two categories: one category analyses an image along a predetermined set of directions, other category adapts the directional analysis itself to the oriented features of image [5]-[8]. Lifting structure based, several adaptive wavelet transforms, which adapt the filtering directions to the orientations of edges and textures, have been proposed [6].

The popular 9/7 filter is one of the bi-orthogonal wavelet filters which is proposed in 1992. This filter has been used as the default filter in the irreversible wavelet transform of the upcoming new still image squeezing standard JPEG2000 [13]-[14]. There are two modes to implement the wavelet transform with the 9/7 filter: First one is convolution-based implementation [12]-[16]-[17] and second one is lifting-based implementation [5]-[11]-[12]. This paper introduces new wavelet based bi-orthogonal filter coefficient that can give better result in case PSNR and MSE comparison to wavelet 9/7 filter and wavelet 5/3 filter.

2. 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)

separable directionally sensitive wavelets

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

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

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

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

Given separable two dimensional scaling and wavelet function, extension of the 1-D DWT to two dimensions is straightforward. Firstly define the scaled and translated basic functions

$$\Phi j,\ m,\ n(x,\ y) = 2^{\frac{j}{2}}\varphi\ (2^j x - m, 2^j y - n) \qquad (5)$$

$$\psi^i j, m, n\ (x,y) = 2^{\frac{j}{2}}(2^j x - m, 2^j y - n) \qquad (6)$$

Where i= {H, V, D}
Where
Index
I: - the directional wavelets
I is a superscript that assumes the values H, V and D.
The discrete wavelet transform of image f(x, y) of size M*N is then

$$W\varphi(jo,m,n) = \frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\varphi jo,m,n(x,y) \qquad (7)$$

$$W^i(j,m,n) = \frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\psi^i j,m,n(x,y) \qquad (8)$$

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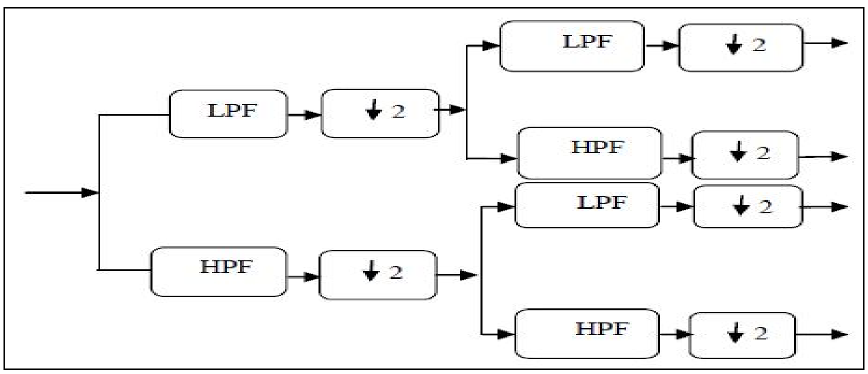

Figure 1: Diagram showing 2-D Fast Wavelet Transform Analysis Filter bank

In the case of one dimensional, arbitrary starting scale is jo and the Wφ (jo, m, n) coefficient define an approximation of f(x, y) at scale jo. The W^i(j, m, n) coefficient add horizontal, vertical and diagonal details for scales jo≤j. We normally let jo=0 and select N=M= 2^J so that j=0,1,2....J-1 and m=n=0,1,2,3 ,4,…2^J-1 The function f(x, y) can be obtained via the inverse discrete wavelet transform

$$F(x,y) = \frac{1}{\sqrt{MN}}\sum_m\sum_n W\varphi(jo,m,n)\varphi jo,m,n(x,y)$$

$$+\frac{1}{\sqrt{MN}}\sum_{i=H,V,D}\sum_{j=jo}^{\infty}\sum_m\sum_n W^i\psi(j,m,n)\,\psi^i j,m,n(x,y) \qquad (9)$$

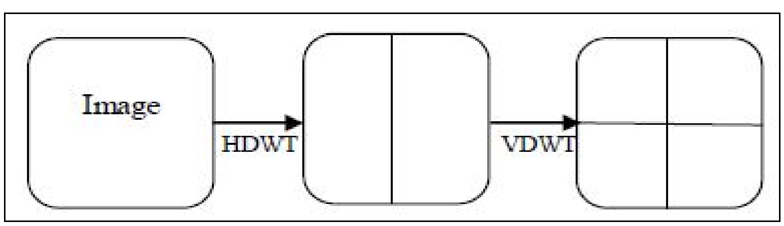

Figure 2: Diagram Showing Sub band generation using Conventional wavelet transform

On the other hand, digital filters and down samplers can be used to implement the 2-D DWT. With separable two dimensional scaling and wavelet function, we simply take the 1-D DWT of the rows of f(x, y), following by the 1-D FWT of the rows of f(x, y), following by the 1-D FWT of resulting columns.

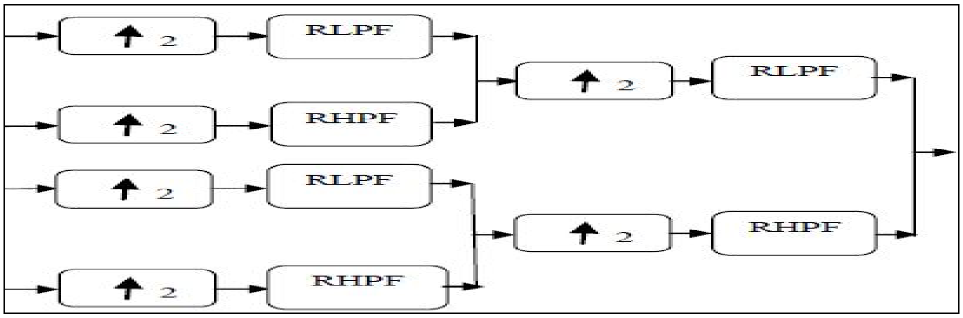

Figure 3: Diagram Showing 2-D Fast Wavelet Transform Synthesis Filter Bank

Note that, like its one-dimensional counterpart, the 2-D FWT filters the scale j + 1 approximation coefficients to construct the scale j approximation and detail coefficients. In the two-dimensional case, however, we get three sets of detail coefficients the horizontal, vertical, and diagonal details.

The single-scale filter bank of Figure can be iterated to produce a P scale transform in which scale j is equal to J — 1, J — 2,..., J — P. As in the one-dimensional case, image f (x, y) is used as the $W\varphi(J, m, n)$ input. Convolving its rows with $h\varphi(—n)$ and $h\psi$ (—n) and down sampling its columns, we get two sub images whose horizontal resolutions are reduced by a factor of 2. The high-pass or detail component characterizes the image's high-frequency information with vertical orientation; the low pass, approximation component contains its low-frequency, vertical information. Both sub images are then filtered column wise and down sampled to yield four quarter-size output sub images $W\varphi$,$W^H\psi$,$W^V\psi$ and $W^D\psi$.

The middle of Fig shows these sub images, are the inner products of f (x, y) and the two-dimensional scaling and wavelet functions followed by down sampling by two in each dimension. In the last portion of figure two scale decomposition are produced by two iterations of the filtering process.

Synthesis filter bank, which is shown in figure 3, are reverses the process comparison to just described process. As would be expected, the reconstruction algorithm is similar to the one-dimensional case. At each iteration, four scale j approximation and detail sub images are up sampled and convolved with two one-dimensional filters—one operating on the sub images columns and the other on its rows. Addition of the results yields the scale j + 1 approximation and the process is repeated until the original image is reconstructed.

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

Table 1: Table Contains 9/7 Filter Coefficient and Proposed Filter Coefficient

Two parameters are measured after reconstruction of image which is:-
Mean square error (MSE) is a distortion measure for glossy Squeezing. The MSE between two image is given as:-

$$MSE=\frac{1}{k}\sum_{i=1}^{k}(Pi-Qi)^2 \qquad (10)$$

The root mean square error is given by:-

$$RMSE=\sqrt{MSE}$$

Where Pi=Original Image data
Qi= Reconstructed Image Data
K= Size of image
The peak signal to noise ratio for reconstructed image is given by:-

$$PSNR= 20\ Log10\left(\frac{Max(Pi)}{RMSE}\right) \qquad (11)$$

3. Algorithm for Squeezing and Coding Of Image
The image squeezing algorithm for proposed schema has following steps:-

3.1. Squeezing
- Firstly image is converted in digital form and read by respective software.
- The RGB image is converted into YCbCr format.
- Separate Y, Cb and Cr component of image.
- Decompose each component by 2-DWT with proposed filter coefficient preliminary plan.
- Code the coefficient of each component by using SPIHT coder.

3.2. *Desqueezing*
- Firstly the coded image is read.
- After that SPIHT encoder are used to decode the coded image
- Pass the decoded image through inverse DWT with proposed filter coefficient.
- The image is converted from YCbCr to RGB format.
- Measure MSE and PSNR for the image.
- Repeat squeezing and desqueezing process by wavelet 9/7 filter coefficient.
- At last, compare the result for both the cases.

4. Image Coding Performance Analysis and Experimental Results
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 preliminary plan is utilized to organize the squeezed bit stream in the squeezing preliminary plan.

4.1. The squeezing ratio is set as the input of the squeezing 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 preliminary plan is better than the old DWT-SPIHT squeezing preliminary plan.

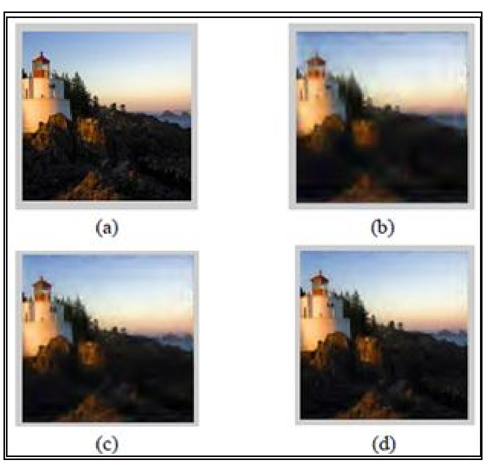

Figure 4: Figure showing (a) house image (b) Recons-trusted Image at 0.1bpp
(c) Reconstructed Image at 0.25 bpp (d) Reconstructed Image at 0.5 bpp

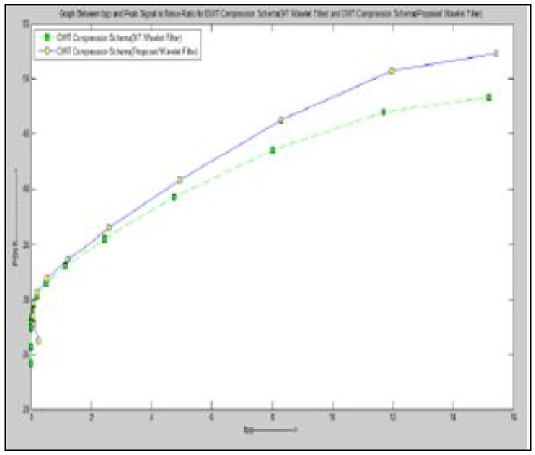

Figure 5: Figure showing Squeezing in PSNR with respect to bpp for Wavelet 9/7 filter based squeezing and proposed filter based Squeezing for house image

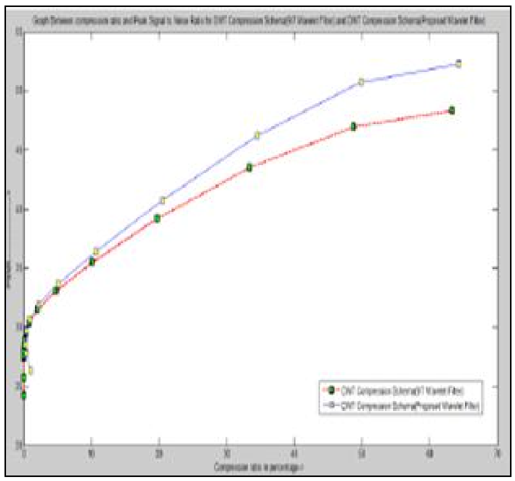

Figure 6: Figure showing Comparison in PSNR with respect to squeezing ratio for Wavelet 9/7 filter based squeezing and proposed filter based Squeezing for house image

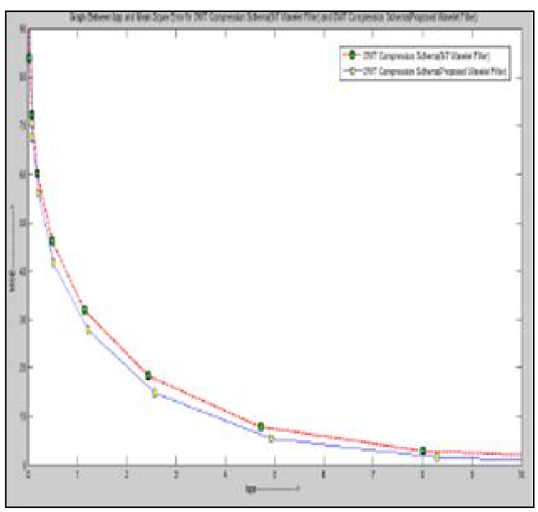

Figure 7: Figure showing Comparison in MSE with respect to bpp for Wavelet 9/7 filter based squeezing and proposed filter based squeezing for house image

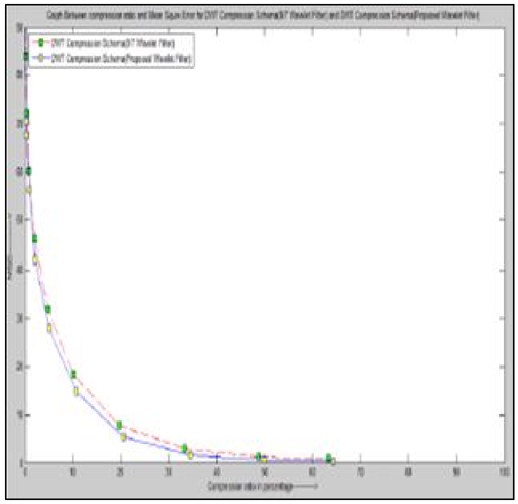

Figure 8: Figure showing Comparison in PSNR with respect to squeezing ratio for Wavelet 9/7 filter based Squeezing and proposed filter based Squeezing for house image

5. Conclusion

In this paper the new wavelet bi-orthogonal filter coefficients are introduced. The proposed filter coefficient with DWT-SPIHT squeezing preliminary plan performs better than DWT-SPIHT squeezing preliminary plan with wavelet 9/7 filter. Our future work includes applying this preliminary plan for wavelet based video coding at low computational complexity.

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