Kavitha Srinivasan, Dr.N.M.Nandhitha, Dr.T.Ravi, Dr.E.Logashsnmugam / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622
www.ijera.com Vol. 2, Issue 2,Mar-Apr 2012, pp.1274-1277

WAVELET BASED HYBRID CODING OF IMAGES

Kavitha Srinivasan M.Tech VLSI Design
Dr.N.M.Nandhitha Professor
Dr.T.Ravi Asst.Professor
Dr.E.Logashsnmugam Prof & Head
Department of Electronics and Communication Engineering
Sathyabama University

ABSTRACT: Recently, several wavelet transform based image coding techniques are reported in literature. Though these schemes yield very low bit rates, they suffer from the drawback of computational complexity. There is always a need for simple, fast and easy to implement image coding techniques that yield good subjective quality at low bitrates. To obtain good data compression, the wavelet transform coefficients are encoded using the scalar or vector quantization. Scalar quantization techniques are simple and fast. Therefore an attempt has been made to derive hybrid coding algorithms by combining the discrete wavelet transform with Modified Block Truncation Coding and New Block Truncation Coding techniques. The performance analysis of these algorithms in terms of subjective quality and quantitative measures such as mean square error, peak signal to noise ratio, compression ratio and bitrate have been carried out on two images viz., Lena & Pepper and the results are found to be encouraging.

Indexing terms: Wavelet transform, Modified Block Truncation Coding, Scalar quantization

INTRODUCTION

Sampling and quantization of a 2-D light intensity function to generate a digital image results in enormous amount of data. The volume of data generated may result in huge storage, large processing time and large video transmission bandwidth. Image data compression deals with the problem of reducing the volume of data required to represent a digital image. Image compression plays an important role in many fields such as tele-videoconferencing, remote sensing, document and medical imaging, Facsimile transmission (FAX) and military applications.

In image processing, wavelet analysis has been mainly used for solving problems such as data compression and noise removal. Recently, the Discrete Wavelet Transform (DWT) has emerged as a powerful tool for decomposing images into various multiresolution approximations (Mallat,1989). The pyramidal algorithm for computing DWT is proposed in (Mallat,1989).

Multiresolution decomposition schemes are known for yielding high quality images at low bitrates (Sri Ram et.al.,1995) . In references (Villasenor et.al.,1995) and (Wang et.al.,1996) different filter banks that can be used in wavelet compression are proposed. As the application of DWT does not result in significant reduction in the bitrate, it has to be combined with scalar and vector quantization techniques for reducing the bitrate further. In references (Wang et.al.,1996) and (Weterink.et.al.,1988) wavelet-based image coding techniques using vector quantization are proposed. Vector quantization techniques are computationally complex and time consuming. On the other hand, scalar quantization techniques discussed in (Gonzalez et.al.,1993) and (Udpikar et.al.,1985) are simple and efficient. Hence the scalar quantization techniques of (Gonzalez et.al.,1993) and (Udpikar et.al.,1985) can be combined with the wavelet transform. In this paper, two hybrid image coding algorithms using wavelet transform and the scalar quantization schemes of (Gonzalez et.al.,1993) are proposed and their performance is compared in terms of mean square error, PSNR, CR, bitrate and subjective quality.

II. DISCRETE WAVELET TRANSFORM AN OVERVIEW

The pyramidal algorithm (Mallat et.al.,1989) is used for wavelet decomposition and reconstruction. In order to apply wavelet decomposition to images, a separable DWT is employed in which emphasis is given to the horizontal and vertical directions. **Fig.1** shows the basic pyramidal structure for 2-D wavelet decomposition. At each step, the image $A_m(f)$ is decomposed into a coarse approximation $A_{m+1}(f)$ and three detail sub-images $D^1_{m+1}(f)$,$D^2_{m+1}(f)$ and $D^3_{m+1}(f)$. The rows of $A_m(f)$ are first convolved with a one-dimensional filter and every other column is retained. Next the columns of the resulting signals are convolved with another one-dimensional filter and every other row is retained. The filters used in this decomposition are the quadrature mirror filters h and g. **Fig.2** shows the disposition of $A_{m+1}(f)$ $D^1_{m+1}(f)$,$D^2_{m+1}(f)$ and $D^3_{m+1}(f)$ obtained after wavelet decomposition.

For reconstruction at each level, the image $A_m[f]$ is reconstructed from $A_{m+1}[f]$, $D^1_{m+1}[f]$, $D^2_{m+1}[f]$ and $D^3_{m+1}[f]$. This algorithm is illustrated in **Fig.3.** Between each column of the sub images

$A_{m+1}[f]$, $D^1_{m+1}[f]$, $D^2_{m+1}[f]$ and $D^3_{m+1}[f]$ a column of zeros is added and the rows are convolved with a one-dimensional filter. A row of zeros is added between each row of the resulting image and the columns are convolved with another one-dimensional filter. The filters used in this reconstruction are the quadrature mirror filters *h* and *g*. In this paper, in the implementation of the pyramidal algorithm for wavelet transform, the convolution operations are performed using Fast Fourier transform.

The impulse response of the filters *h* and *h* are referenced from Wang et.al,1996. After wavelet decomposition or reconstruction, any pixel value found greater than 255 is limited to 255 and any pixel value less than zero is limited to zero. **Figs.4 and 5** show the original Lena image of size 256*256, the one-level wavelet decomposition of and reconstructed image after performing WT-MBTC and WT-NBTC compression technique on Lena image respectively. The detailed sub-images are ignored for simplicity, as they do not contain significant energy.

With these approximations, the bitrate is

$$\text{bits per pixel (bpp)} = \frac{128 * 128 * 8}{256 * 256} = 2 \text{ bpp.}$$

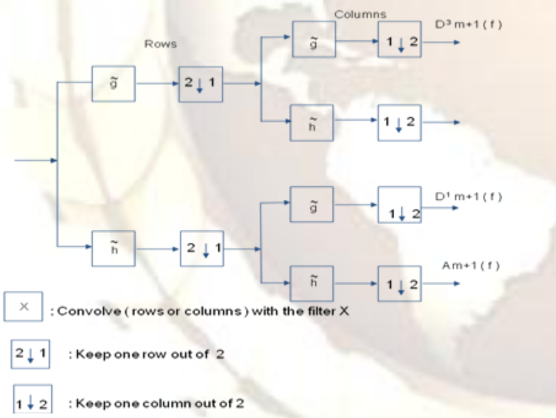

Fig 1. Pyramidal Algorithm for 2D Wavelet Decomposition

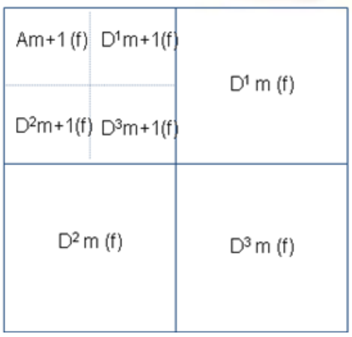

Fig 2. Wavelet Decomposed Sub Images

III. PROPOSED ALGORITHMS

In this section, two wavelet based hybrid image-coding algorithms are proposed in order to reduce the bitrate further. The algorithms considered together with the Wavelet Transform (WT) are

1. Discrete Wavelet Transform with Modified Block Truncation Coding **(DWT- MBTC)** algorithm.

2. Discrete Wavelet Transform with New Block Truncation Coding **(DWT- NBTC)** algorithm.

The aforementioned algorithms are applied on the approximation sub image obtained after one-level wavelet decomposition of the original image. The proposed algorithms are discussed below.

WT-MBTC ALGORITHM:

In the Encoder side,

- From the one-level wavelet decomposition of the original image computed, the three detail sub-images are eliminated. The approximation image obtained after one-level wavelet decomposition is divided into non-overlapping blocks of size n*n. Therefore each block contains n*n pixel values. For each block, STEP 3-6 is performed. The average value of the pixels is computed.

- The pixels in the block are divided into two groups-one group containing pixel values greater than or equal to x', and the other group containing pixel values less than x'. The average value of the pixel values less than x' i.e., x_L' is computed.

- A bit plane of size n*n is constructed such that each pixel location is coded as '1' if the pixel value is greater than or equal to x' and coded as a '0' if it is less than x'. For each block x', x_L', and bit plane are transmitted.

In the Decoder side,

- At the receiver, the average value of pixels greater than x',i.e., x_H' is computed as given in equation.

$$x_H' = x_L' + (n^2/q)\ (x' - x_L')$$

where q is the number of pixels greater than or equal to x'.

- The image block is reconstructed by using x_L' and x_H' and these values are assigned in accordance with the code in the bit plane. If a bit in the bit plane is a ‘0’, x_L’ is used for that pixel location. If a bit is ’1’, x_H’ is used.

- Any pixel value greater than 255 or less than 0 is limited to 255 or 0 respectively.

- The inverse wavelet transform of the reconstructed approximation sub-image obtained is computed using the pyramidal reconstruction procedure illustrated in **Fig.3&4**

WT-NBTC ALGORITHM

In the Encoder side,

- The one level wavelet decomposition of the original image is computed and the three detail sub-images are eliminated.

- The approximation image obtained after one-level wavelet decomposition is divided into non-overlapping blocks of size n*n .Therefore each block contains n*n pixel values. For each block, STEPS 3-11 are performed. The average value of the pixels, x’, is computed. The difference between each pixel value of original image block and x’ is computed.

- A sign plane of size n*n is constructed such that each pixel location is coded as a “0” , if the difference is greater than or equal to “0” and coded as a “1” if it is less than “0”.

- The signs of difference values are dropped giving rise to absolute difference values. The average value of the absolute difference values, x_d’ , is computed.

- The absolute difference values in the block are divided into two groups – one group containing values greater than or equal to x_d’ and the other group containing values less than x_d’. The average value of the absolute difference value less than x_d’ i.e., x_{ld}’ is computed.

- A bit plane of size n*n is constructed such that each absolute difference value location is coded as a “1” if the absolute difference value is greater than or qual to x_d’ and coded as a “0” if it is less than x_d’. For each block ,**x’, x_d’, x_{ld}’, bit plane and sign plane** are transmitted.

In the Decoder side,

- At the receiver, the average value of the absolute difference values greater than x_d’, i.e., x_{hd}’ is computed as given in equation.

$$x_{hd}’ := x_{ld}’ + (n^2/q)\,(x_d’ - x_{ld}’)$$

- q is the number of absolute difference values greater than or equal to x_d’ Absolute difference block is reconstructed using x_{ld}’ and x_{hd}’. These values are assigned to absolute difference location in accordance with code in the bit plane. If a bit in bit plane is “0”, x_{ld}’ is used and if “1”, x_{hd}’.

- The image block is reconstructed using the reconstructed absolute difference values and the sign plane. If a bit in the sign plane is“1” the original value is by adding the reconstructed absolute difference value to x’. If a bit in the sign plane is a “0” the original value is by subtracting the reconstructed absolute difference value from x’.

- Any pixel value greater than 255 or less than 0 is limited to 255 or 0 respectively. The inverse wavelet transform of the reconstructed approximation sub-image obtained is computed using the pyramidal reconstruction procedure illustrated in **Fig 3&4.**

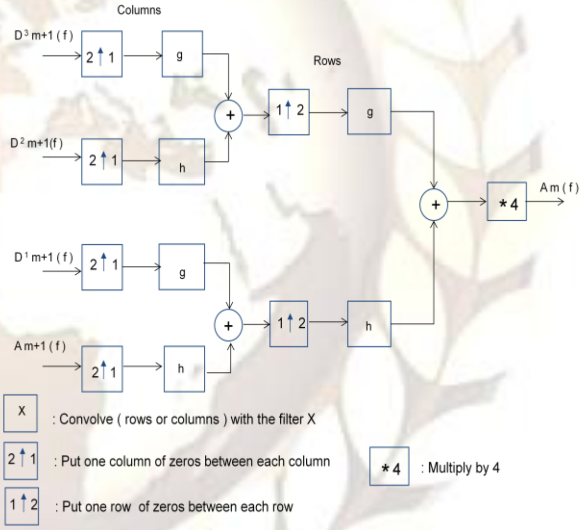

Fig 3. Pyramidal Algorithm for 2D Wavelet Reconstruction

IV. PERFORMANCE ANALYSIS

The performance of the proposed algorithms is compared in terms of quantitative measures and subjective quality.
Quantitative Measures :

The parameters chosen for quantitative analysis are Mean Square Error **(MSE)**, bits per pixel **(bpp)**, Peak Signal to Noise Ratio **(PSNR)** and Compression Ratio **(CR).**

Algorithm	Block	Bits Per Pixel (bpp)	Mean Square Error (MSE)	Peak Signal to Noise Ratio (PSNR)	Comp. on Ratio (CR)
WT	-	2	23.3924	79.3012	4:1
MBTC	4X4	2	28.7348	77.2442	4:1
NBTC	4X4	3	20.642	79.728	3:1
WT-MBTC	4X4	0.5	63.2307	69.3574	11:1
WT-NBTC	4X4	0.75	39.9372	73.9522	16:1

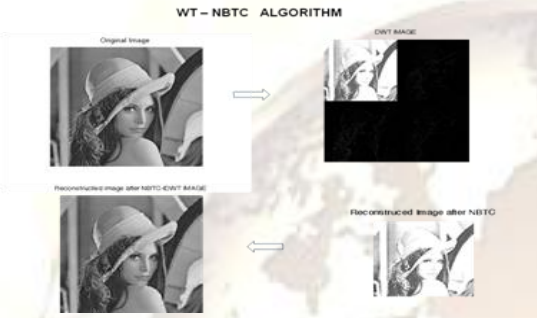

Fig 4 : WT-MBTC algorithm on Lena image

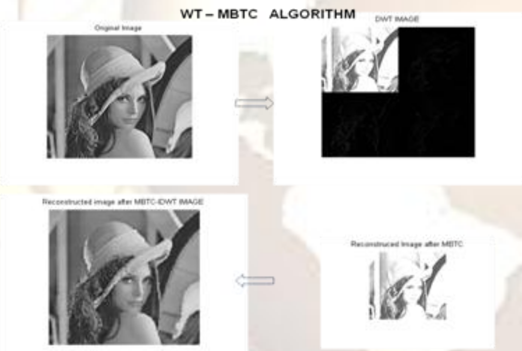

Fig 5 : WT-NBTC algorithm on Lena image

V CONCLUSION

The results obtained using the WT-MBTC algorithm are compared with those obtained using the WT-NBTC algorithm.In this paper, two new wavelet based hybrid image coding techniques using modified block truncation coding and new block truncation coding have been proposed. . The performance of the algorithms is compared in terms of mean square error, PSNR, CR and bit rate values for different quality factors. The trade-off between these two techniques must be done based on the applications. If compression ratio is of greater importance then WT-MBTC has to be chosen. On the other hand, if the quality of the picture is more important then WT-NBTC has to be favoured.

REFERENCES

[1]. Mallat.S,"Theory for multiresolution signal decomposition the wavelet representation", IEEE Trans. on Pattern Analysis & Machine Intelligence, vol.11. pp 674-693, July' 89.

[2] Sriram.Pand Marcellin.M.Wage coding using wavelet transform and entropy constrained Trellis-coded Quantization", IEEE Trans. on Image Processing, vol.4. pp 725-733, June' 95.

[3] Villasenor.J.D, Benjamin Belzer and Judy Liao, "Wavelet filter evaluation for image compression", IEEE Trans on Image Processing,vol.4. pp 1063-1070, Aug '95.

[4] Wang.X, Chan.E, Mandal.M.K and Panchanathan.S, "Wavelet based image coding using Non interpolative vector quantization", IEEE Trans.on Image Processing, vol.5. pp 518-521, Mar '96.

[5] Weterink.P, Boekee.D and Woods.J, "Subband coding of images using vector quantization", IEEE Trans. on communications, vol.36. pp 715-719, June' 88.

[6] Gonzalez.R and Woods.R, Digital Image Processing, Addison Wesley, Sept' 93.

[7] [Udpikar.V, Raina.J.P, "Modified algorithm for block truncation coding of monochrome images", Electronic Letters, vol.21. pp 900 - 902, Sept' 85.