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AN ENHANCED BI-ORTHOGONAL WAVELET FILTER FOR IMAGE COMPRESSION

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ABSTRACT

Image processing is the latest field of research now days. A lot of work has been done over the topic and still is in progress. Image processing consists of various fields like Image Segmentation, Image Compression and Image Enhancement. Wavelets are the well-known transform methods in the field of Image Compression. In this paper, weighted coefficients of biorthogonal filter '*bior4.4*' are modified to make them more energy preserving and to get higher compression score. An algorithm is proposed with the new weighted coefficients. Then the new weighted coefficients are used for the image compression. High compression ratio is required when the images are transferred over the network. Results are compared with the existing state of art wavelet filters qualitatively as well as quantitatively. It is observed that Retain Energy and Compression score parameters have increased with proposed algorithm at the cost of little degradation in PSNR.

Keywords: Image, Compression, Wavelet Transform, Filter, Biorthogonal.

1. INTRODUCTION

Image compression addresses the problem of reducing the amount of data required to represent a digital image. The basis of the reduction process is the removal of redundant data. From a mathematical viewpoint, the process of compression consists of transforming a 2-D pixel array into a statically uncorrelated data set. The transformation is applied prior to storage or transmission of the image. After this process, whenever the original image is required, then the compressed image is decompressed to construct the original image or an approximation of it.

The initial focus was on the development of analog methods for reducing video transmission bandwidth, called Bandwidth Compression. However, with the development of digital computers and advancement of integrated circuits, the interest shifted from analog to digital compression approaches. Image compression is the natural technology for handling the increased spatial resolutions of today's imaging sensors and evolving broadcast television standards. Image Compression plays a major role in many important applications that include television conferencing, remote sensing, document and medical imaging, facsimile transmission, and the control of remotely piloted vehicles in military and space etc. (Gonzalez and Woods, 2004).

Compressing an image is different than compressing binary data. General-purpose compression programs can be used to compress images, but the results are less than optimal. This is because images have certain statistical properties. Also, some of the finer details in the image can be sacrificed for saving a little more bandwidth or storage space.

A wavelet is a waveform of effectively limited duration that has an average value of zero. Wavelet analysis is the breaking up of a signal into shifted and scaled versions of the original wavelet. Wavelet transform affords wide space for image coding algorithms because of its excellent space-frequency localization characterizations. The compact supported, symmetrical and biorthogonal wavelet has linear phase, so it is applied on image compression area widely (Liu et al., 2005).

2. RELATED WORK

Rao and Borpardikar (2004) in the book "Wavelet Transform : Introduction to theory and applications" have described the evolution of Wavelet Theory. Wavelets provide an elegant alternative to sinusoidal representation of local details of signal. Wavelets attract attention of researchers because of their inherent simplicity and flexibility. Sarita et al. (2008) in the paper, "*Performance Analysis of Image Compression with different wavelet families*", obtained that higher the decomposition level the higher percentage of zeros obtained with the fixed thresholding. This is because decomposing to greater levels means that a higher percentage of coefficients come from detail sub signal. Raj et al. (2008) in their paper, "*Study on the Choice of Wavelet Filters for Image Compression using Neural and k-Nearest Neighbor Classifiers*", worked over the selection of wavelet filters for better compression performance. They used different classifiers like neural, nearest neighbor, discriminant and classification tree to predict the best filter for image compression based on image features. Balasingham and Ramstad (2008) in the paper, "*Are the Wavelet Transforms*

the Best Filter Banks for Image Compression?", generate all possible 9/7 filter banks with perfect reconstruction and linear phase, while having a different number of zeros at $z = -1$ for both analysis and synthesis lowpass filters. The best performance is obtained when the filter bank has 2/2 zeros at $z = -1$ for the analysis and synthesis lowpass filters. Veeraswamy and Kumar (2008) in the paper, "*An Improved Wavelet based Image Compression Scheme and Oblivious Watermarking*", presents a novel procedure to improve the performance of Wavelet based image compression in terms of entropy. Kharate et al. (2007) in the paper, "*Selection of Mother Wavelet for Image Compression on Basis of Nature of Image*", compared the compression performance of Daubechies, Biorthogonal, Coiflets and other wavelets along with results for different frequency images. Gornale et al. (2007) in the paper, "*Performance Analysis of Biorthogonal Wavelet Filters for Lossy Fingerprint Image Compression*", performed analysis on performance of biorthogonal wavelet filters for lossy fingerprint image compression.

3. PRESENT WORK

3.1 Problem Formulation

The choice of research is biorthogonal wavelet filters. Biorthogonal wavelet filters have the problem of being non-energy preserving. Wavelets provide a large number of linear phase biorthogonal filters ranging from '*bior 1.1*' to '*bior 6.8*'. Work is done to make the biorthogonal wavelet filters more energy preserving by making modifications in the weighted coefficients of biorthogonal wavelets filters.

3.2 Design and Implementation

The proposed algorithm is implemented using Wavelet Toolbox on MATLAB environment. For implementing this algorithm Image processing toolbox is also used. Wavelet functions that are provided in the MATLAB are used for decomposition and compression.

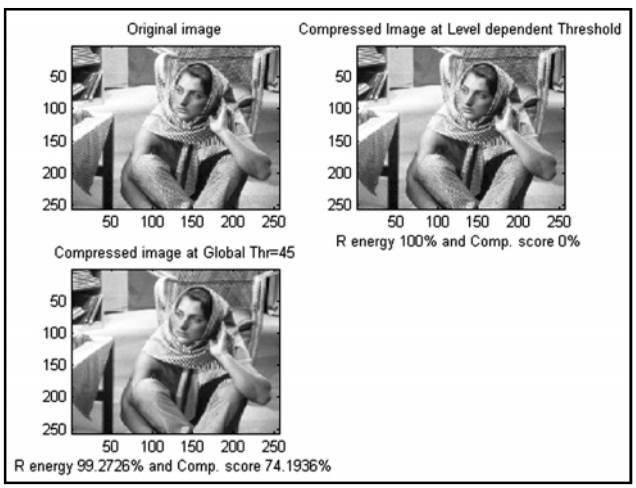

Figure 1: Sample Output of the Proposed Algorithm

The image is decomposed in the specified levels (ranging from 1 to 5) using wavelet decomposition function. Then, the image compression function of wavelet toolbox is applied and the values for performance metrics are calculated.

3.3 Proposed Algorithm

All the parameters of performance metrics could not be better than the existing results for any particular class of image. Thus, to improve the '*Retain Energy*' and '*Compression Score*' an algorithm is proposed.

***Input: Image* – An original image.**

Algorithm:

Step I: Load the original image into MATLAB workspace.

Step II: Set the decomposition level equal to 1 and wavelet name equal to bior4.4.

Step III: Decompose the image using decomposition coefficients of bior4.4 filters and reconstruction coefficients that are proposed as follows: -

Decomposition Coefficients

= [.026748757411, –.016864118443, –.078223266529, .266864118443, .602949018236, .266864118443, –.078223266529, –.016864118443, .026748757411]

Reconstruction Coefficients

= [**–.025635881557**, **–.008771763114**, .295635881557, .557543526229, .295635881557, **–.008771763114**, **– .025635881557**]

%Coefficients in bold letters are proposed%

Step IV: Find the level dependent threshold '*lvd*' and the number of coefficients to keep '*nkeep*' using decomposed structure and the advised parameters alpha=1.5, m=6*prod(s(1,:)).

Step V: Compress the original image using above details and hard thresholding.

Step VI: Plot the original image and reconstructed image. Calculate their Retain Energy, Compression Score, PSNR for reconstructed image.

Step VII: Now consider the global threshold as 45 and compress the original image using remaining parameters same. Also keep the approximation coefficients equal to one.

Step VIII: Plot the reconstructed image with the parameters as in STEP 5.

Step IX: Repeat STEPS 3 to 8 for levels 2 to 5.

Step X: STOP.

Output: **Reconstructed images with the three parameters *'Retain Energy', 'Compression Score', 'PSNR'* for (a) Level dependent threshold (b) Global threshold=45.**

4. RESULTS AND DISCUSSION

The proposed algorithm (using proposed biorthogonal wavelet filters) is applied on the original image. The results are compared qualitatively/subjectively (visually) as well as quantitatively/objectively using three performance metrics (*i.e.* '*Retain Energy*', '*Compression Score*', '*PSNR*').

Comparative results are shown in table 1 & 2 for five wavelet filters named '*Haar*', '*db2*', '*sym4*', '*bior4.4*' and '*proposed wavelet filters*' from decomposition level 1 to level 5. The values for the parameters '*Retain Energy*' and '*Compression Score*' are larger for the proposed filters than other state-of-art wavelet filters. Thus, it can be proved from the below shown results that the proposed filters perform better than existing filters.

Table 1
Retain Energy, Compression Score, PSNR of Wbarb by Different Wavelet Filters on Global Threshold=45.

Sr. No.	*Wavelet Type*	*Level*	*Retain Energy*	*Compression Score*	*PSNR*
1	**Haar**	1	99.064	73.9731	28.706
		2	98.6945	91.4749	27.2606
		3	98.568	94.9493	26.8612
		4	98.541	95.3964	26.7792
		5	98.5383	95.4422	26.7697
2	**db2**	1	99.19	74.19	29.338
		2	98.9117	91.7093	27.9108
		3	98.8433	95.4389	27.4267
		4	98.927	95.956	27.3206
		5	99.101	95.9679	27.3045
3	**sym4**	1	99.2551	74.1857	29.6803
		2	99.04	91.4416	28.3156
		3	99.068	95.0435	27.8139
		4	99.2518	95.4896	27.7036
		5	99.5063	95.4337	27.6928
4	**bior4.4**	1	**99.27**	**74.1936**	29.6532
		2	**99.0643**	**91.5169**	28.2967
		3	**99.11**	**95.1654**	27.7636
		4	**99.352**	**95.6947**	27.6214
		5	**99.6054**	**95.6507**	27.6088
5	**Proposed**	1	**99.3736**	**74.4275**	29.1604
		2	**99.1807**	**91.8967**	27.4568
		3	**99.2141**	**95.6677**	26.2908
		4	**99.4261**	**96.2432**	25.2772
		5	**99.6494**	**96.2187**	24.3989

Table 2
Retain Energy, Compression Score, PSNR of Wbarb by Different Wavelet Filters on Level Dependent Threshold

Sr. No.	*Wavelet Type*	*Level*	*Retain Energy*	*Compression Score*	*PSNR*
1	**Haar**	1	100	2.99	318.6247
		2	99.645	67.9047	32.9248
		3	98.818	90.79	27.695
		4	97.5118	97.4867	24.4595
		5	95.1282	99.3332	21.5415
2	**db2**	1	100	0	263.987
		2	99.7516	66.659	34.2835
		3	99.188	89.9046	28.9187
		4	98.4772	96.9128	25.8068
		5	97.5476	98.9901	23.0981
3	**sym4**	1	100	0	264.88
		2	99.81	65.202	35.32
		3	99.4235	88.08	29.732
		4	99.0534	95.6715	26.665
		5	99.8154	98.1447	24.0871
4	**bior4.4**	1	**100**	**0**	259.97
		2	**99.827**	**64.857**	35.4034
		3	**99.467**	**87.7067**	29.829
		4	**99.2661**	**94.9756**	27.0336
		5	**99.216**	**97.6389**	24.6013
5	**Proposed**	1	**100**	**0**	41.1645
		2	**99.8632**	**64.857**	32.7574
		3	**99.5767**	**87.7067**	27.979
		4	**99.4106**	**94.9756**	25.1824
		5	**99.3624**	**97.6389**	22.9606

5. CONCLUSION AND FUTURE SCOPE

Wavelets have the ability to produce the information about time and frequency both. Very large numbers of wavelets are available for transformation including '*Haar*', '*daubetchies*', '*Symlets*', '*Coieflets*', '*Orthogonal*', '*Biorthogonal*'. In this paper, biorthogonal wavelet family is considered as the main objective. *Weighted coefficients of biorthogonal wavelet filter bior4.4 are modified to make them more energy preserving*. The reason for choosing only biorthogonal family is the availability of large range of linear phase filters in this family. In the proposed algorithm, *an enhanced biorthogonal filter is used for the image compression*. And experimental results show that the proposed filter is slightly better than existing filters. Thus on the basis of the above results, it is concluded that:

a) Retain Energy is more in image compression using proposed filter as compared to existing biorthogonal filter.

b) Compression Score is slightly high as compared to existing filter in case of global thresholding.

c) PSNR is little lesser as compared to results of existing biorthogonal wavelet filters.

d) It is further concluded that results at levels 4 and 5 retain more energy.

For future work, it would be interesting to modify the other wavelet filters to retain more energy and more compression score. Till now only still images are taken into consideration, animated videos and other videos could be considered for further research. To obtain better PSNR values with more retain energy and more compression score can be considered as further research work.

REFERENCES

[1] Balasingham, Ilangko and Ramstad, Tor A. (2008), "Are the Wavelet Transforms the Best Filter Banks for Image Compression?", *EURASIP Journal on Image and Video Processing*, Vol. 2008, Article ID 287197.

[2] Gonzalez, Rafael C. and Woods, Richard E. (2004), "Digital Image Processing", Pearson Education Inc., India, 2nd Edition, pp. 349-510.

[3] Gonzalez, Rafael C., Woods, Richard E. and Eddins, Steven L. (2007), "Digital Image Processing using MATLAB", Pearson Education Inc., India, 2nd Impression, pp. 256-347.

[4] Gornale, S. S., Manza, R. R., Humbe, Vikas and Kale, K. V. (2007), "Performance Analysis of Biorthogonal Wavelet Filters for Lossy Fingerprint Image Compression", *International Journal of Imaging Science and Engineering (IJISE)*, GA, USA, **1**, No. 1, pp. 16-20.

[5] Grasemann, Uli and Miikkulainen, Risto (2005), "Effective Image Compression using Evolved Wavelets", *GECCO'05*, Washington, DC, USA.

[6] K., Sarita, V., Ritu and Meel, V. S. (2008), "Performance Analysis of Image Compression with Different Wavelet Families", *2nd National Conference Mathematical Techniques: Emerging Paradigms for Electronics and IT Industries (MATEIT 2008)*, pp. 342-346.

[7] Kharate, G. K., Patil, V. H. and Bhale, N. L. (2007), "Wavelet for Image Compression on Basis of Nature of Image", *Journal of Multimedia*, **2**, No. 6, pp. 44-51.

[8] Liu, Hong, Zhai, Lin-pei, Gao, Ying, Li, Wen-ming and Zhou, Jiu-fei (2005), "Image Compression Based on Biorthogonal Wavelet Transform", *IEEE International Sumposium on Communications and Information Technology*, **1**, pp. 598-601.

[9] Raj, S. Gladston, Revathy, K. and Raju, G. (2008), "Study on the Choice of Wavelet Filters for Image Compression using Neural and *k*-Nearest Neighbor Classifiers", *Journal of Wavelet Theory and Applications*, ISSN 0973-6336, **2**, No. 1, pp. 15-30.

[10] Rao, R. M. and Borpardikar, Ajit S. (2004), "Wavelet Transform: Introduction to Theory and Applications", Pearson Education, India.

[11] Veeraswamy, K. and Kumar, S. Srinivas (2008), "An Improved Wavelet Based Image Compression Scheme and Oblivious Watermarking", *International Journal of Computer Science and Network Security (IJCSNS)*, **8**, No. 4, pp. 170-177.