Middle-East Journal of Scientific Research
24 (Special Issue on Innovations in Information, Embedded and Communication Systems): 138-142, 2016
ISSN 1990-9233; © IDOSI Publications, 2016
DOI: 10.5829/idosi.mejsr.2016.24.IIECS.23152

Performance Evaluation of Image Compression in Walsh Wavelet Transform Using Wavelet Threshold

R. Naveenkumar, B.N. Jagadale and K.S. Sandeepa

Department of Electronics, Kuvempu University, Shankaragatta-577451, Karnataka, India

Abstract: Wavelet based image coding of JPEG2000's core coding system defined in part one provides a room to improve a performance of image compression. But the development of hybrid Wavelet algorithms in last few years indicates their performance is far better than Wavelet method. This paper introduces new hybrid compression algorithm using Walsh wavelet transforms with variable wavelet threshold. Wavelet decomposition splits an image into low-frequency and high-frequency sub-bands. Application of 2D Walsh transform to low-frequency subband gives DC values and multi-array matrix. At the same time, high-frequency sub-bands at level one are ignored and level two sub-bands are compressed by wavelet threshold and quantization. Encode both the sub-bands by arithmetic code. Compression performance is analyzed by calculating PSNR and Compressed size with different quantization Factors for two grayscale images.

Key words: Discrete Wavelet Transform (DWT) · Walsh Transform · Quantization

INTRODUCTION

Recent developments in digital communication attract many researchers towards the development of smart digital devices. Data compression is one of the major issues in recent technology aimed to reduce the hardware size and its transmission rate. Most popular transform based compression algorithms like JPEG and JPEG2000 are designed by Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT). But DCT based algorithms suffered by blocking artifacts and Wavelet based algorithms have a problem of versatility along application [1]. But Walsh transform is sub-optimal, nonsinusoidal orthogonal transform that decomposes the signal into the set of Walsh functions and no need of multipliers because of its limited values(+1 to -1). Hybrid Wavelet with Walsh Transform reduces the false contouring significantly blocks the artifacts and increase the quality by good reconstruction capability [2, 3].

The paper is organized as follows: The proposed compression and decompression algorithm is explained in section II. The simulation results are given and discussed in section III. Conclusions are presented in section IV.

Proposed Algorithm: Two level decomposition splits an image into seven sub-bands (LL2, LH2, HL2, HH2, LH1, HL1, HH1). Ignore level1 high-frequency subbands and apply the soft and hard threshold for level2 sub-bands along with quantization to compress level2 high-frequency sub-bands. At same time apply two-dimensional Walsh transform to each 8X8 row and column of LL2 subband to get DC values and multi-array matrix then quantizes them. Encode all subbands by using Arithmetic code. Decompressions performed by applying inverse Walsh transform to LL2 sub-bands with de-quantization. Finally, apply IDWT and convert them into RGB image to get reconstructed image.

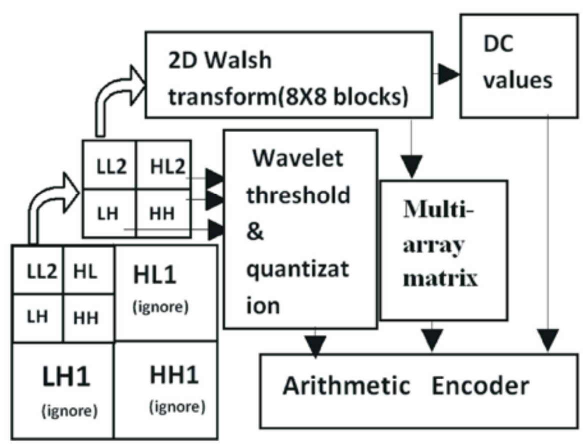

Fig. 1: Block diagram of proposed compression algorithm

Corresponding Author: R. Naveenkumar, Department of Electronics, Kuvempu University, Shankaragatta-577451, Karnataka, India.

Use of Discrete Wavelet Transform: Property of Multiresolution analyzes of wavelet demines offer the great choice for image processing applications. It uses two set of functions as scaling and mother wavelet associated with low and high pass filters orderly. These functions split the signals into two classes (Approximate and detail) of frequency sub-bands for defined scale [4]. It made less number of samples are enough to represent original signal. For each level decomposition of source image produces four sub-bands. As decomposition level increases frequency sub-bands undergoes partition and information details shifted towards left corner meanwhile high-frequency subband become more insignificant. Hence ignoring them achieves more compression [5, 6]. In Two levels Decomposition, LL2 subband contain most significant information. But HL1, LH1, HH1 has very least significant information they made zero or ignored. But HL2, LH2, HH2 are had some little significant information. Therefore instead of direct encoding or ignoring leads to less image quality, hence, apply the optimal threshold and then encoding is key to achieving good compression and quality performance.

Quantization: Two levels of quantization are required. Level1 quantization to reduce the size of LL2 by ratio of maximum value of LL2 and Quality factor, as shown below:

$$Q1 = Quality\ factor \times \max(LL2) \quad (1)$$

$$LL2 = round\left(\frac{LL2}{Q1}\right) \quad (2)$$

Quality factor in equation (1) indicates the quality of an image. Obtained by maximum values in LL2 is divided by all the values in LL2. It helps to make LL2 subband coefficients more convergence. Level2 Quantization performed after Walsh to LL2 subband and then divides the matrix by Q2. Similar procedure followed to high-frequency subband with defined quantization factor, which eliminates the insignificant coefficients by inserting zeros [6].

$$Q2(m,m) = \begin{cases} 1, & if\,(m=1, n=1) \\ m+n+R & if\,(m \neq 1, n \neq 1) \end{cases} \quad (3)$$

Use of Discrete Walsh Transform: The matrix product of set of data 'd' and a matrix of basis vectors consisting of Walsh functions is called Walsh Hadamard transform(WHT). The two dimensional foreword WHT defined by;

$$H(u,v) = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} P_{xy}\, g(x,y,u,v) \quad (4)$$

where H(u, v) are the results of the transformed WHT coefficients, similarly its inverse WHT is

$$P_{xy} = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} H(u,v)\, h(x,y,u,v) \quad (5)$$

where, g(x, y, u, v) and h(x, y, u, v) are called the kernels(basis of image) of WHT [7].

The LL2 sub-bands are partitioned into 8X8 blocks and apply the Walsh transform and Quantization for each block (divide each block by quantization factor). The 8X8 block converted into DC values of the single array and 63 coefficients stored in the new array called the multi-array matrix. DC values are directly attached to the compressed header file but 63 coefficients are compressed by arithmetic coding.

High-Frequency Sub-Band Coding: Instead of direct elimination of zeroes in HL2, LH2, HH2 subbands, optimization of these sub-bands with wavelet threshold and then application of EZSD increase the compression without altering image quality. This paper introduces wavelet threshold for the high-frequency subband.

Wavelet Threshold: This step eliminates the weak high-frequency coefficients and energized the significant coefficients using low-frequency coefficients. Note that high-frequency subbands do not contain signal energy often do not reside at zero or near zero, as do their parent high-frequency subband. Hence, thresholding schemes will be applied to high-frequency sub-band. There is two standard thresholds are there,

- *Hard Threshold*: It zeroes out, or shrink, the coefficient that has magnitudes below the threshold and leaves the rest of the coefficients uncharged

$$T_{har}(d, \lambda) = dl(|d| > \lambda) \quad (6)$$

- *Soft Thresholding*: It shrinks the magnitude of the remaining coefficients by T, producing a smooth rather than abrupt transition to zero.

$$T_{soft}(,\lambda) = (d - sgn)(d)\lambda)dl(|d| > \lambda) \quad (7)$$

There are several thresholding techniques used to analyze the image compression but in this paper, we use soft and hard threshold for good compression performance. Thresholded coefficients are quantized (Each sub-band divided by quantization factor) and encoded by arithmetic coding [8].

Arithmetic Coding and Decoding: It plays very important role in compressing a stream of data sequence into one-dimensional length code word along with calculating the probability. Run Length encoding helps to avoid coding of repeated coefficients by a value, which reduces the length of the codeword. Arithmetic code converts codeword into bit streams [9].

Decompression Steps:

It follows two steps,

- Decode DC values and multi-matrix array by an arithmetic decoder and apply 2D IDCT to get LL2.
- Decode all high-frequency subbands and apply IDWT for all sub-bands.

Arithmetic decoders decode one-dimensional array and matrix, then apply inverse quantization and inverse WHT for each row and repeat the process until all rows are completed. Then apply IDWT for first level reconstruction by using LL2, HL2, LH2, HH2 to get LL1. Second level reconstruction by LL1 with ignored HL1, LH1, HH1 gives approximated original image [10].

RESULTS AND DISCUSSIONS:

Figure 2 shows original tested images 'Lena', 'Barbara' respectively. These Images tested by INTEL core to duo core processor, MATLAB R2009a as a programming language with operating system windows-7(32-bits). Table 1 shows tabulated compression performance with variable hard and a soft threshold at three quality factors and threshold (10-80). Figure 3 shows PSNR and Compression performance plots with variable threshold and quality factor. Figure 4 and 5 shows decoded Lena and Barbara image from our approach.

Fig. 2: Tested images in our approach.(a) Lena image, size 245KB, dimension(500 x 500);(b)Barbara image, size 257KB, dimension(512 x512)

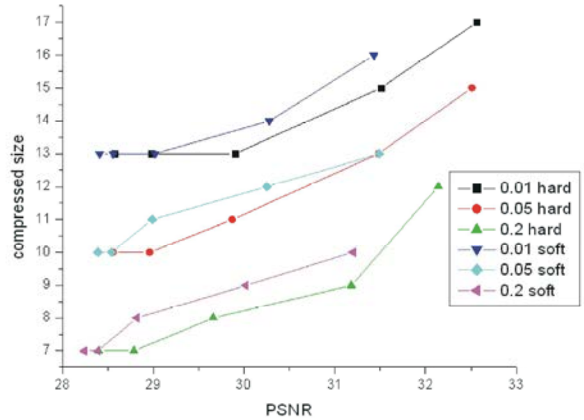

Fig. 3: PSNR and compressed size variation with different quality and threshold (for Lena image)

Fig. 4: Decoded Lena image with different quality by our approach with hard threshold (10). (a)Decoded image with Quality 0.01, PSNR =32.56; (b)Decoded image with Quality 0.05, PSNR =32.51; (c)Decoded image with Quality 0.2, PSNR =31.14.

Fig. 5: Decoded "Barbara" image with different quality by our approach with hard threshold 10. (a)Decoded image with Quality 0.01, PSNR =25.63; (b)Decoded image with Quality 0.05, PSNR =25.62; (c)Decoded image with Quality 0.2, PSNR =25.53;

In JPEG2000 standard image compression, DWT is used for multi-level decomposition to partition the image into a large number of coefficients and encoded by arithmetic coding [11, 12]. But here two level decomposition used with tunable threshold values. Measuring PSNR doesn't decide the perfect performance of image because of calculation of MSE gives highest value than the existed brightness values and variation in brightness gives very high PSNR value. Hence Human visual system used for measuring the differences [13].

Table 1: Compression performance with variable hard and soft threshold

			Hard Threshold			Soft Threshold		
Image type(Size)	Quantization factor for LL2	Threshold	PSNR	Compressed Size	Time elapsed to compress the file	PSNR	Compressed Size	Time elapsed to compress the file
Lena(245KB)	0.01	10	32.56	17KB	4.64Sec	31.43	16KB	4.37Sec
		20	31.51	15KB	4.14Sec	30.28	14KB	4.09Sec
		40	29.90	13KB	3.84Sec	29.02	13KB	3.83Sec
		60	28.98	13KB	3.77Sec	28.56	13KB	3.82Sec
		80	28.58	13KB	3.39Sec	28.41	13KB	3.43Sec
	0.05	10	32.51	15KB	4.29Sec	31.49	13KB	3.95Sec
		20	31.48	13KB	3.80Sec	30.25	12KB	3.74Sec
		40	29.87	11KB	3.49Sec	28.99	11KB	3.47Sec
		60	28.96	10KB	3.42Sec	28.54	10KB	3.36Sec
		80	28.56	10KB	3.03Sec	28.39	10KB	3.06Sec
	0.2	10	32.14	12KB	3.75Sec	31.20	10KB	3.39Sec
		20	31.18	9KB	3.24Sec	30.02	9KB	3.12Sec
		40	29.66	8KB	2.97Sec	28.82	8KB	2.91Sec
		60	28.79	7KB	2.87Sec	28.39	7KB	2.80Sec
		80	28.40	7KB	2.45Sec	28.24	7KB	2.50Sec
Barbara(247KB)	0.01	10	25.63	23KB	6.08Sec	25.24	20KB	7.12Sec
		20	25.25	19KB	5.58Sec	24.66	18KB	6.39Sec
		40	24.40	16KB	4.62Sec	23.99	16KB	6.12Sec
		60	23.93	15KB	4.43Sec	23.79	15KB	5.88Sec
		80	23.77	15KB	3.69Sec	23.74	15KB	4.88Sec
	0.05	10	25.62	20KB	5.54Sec	25.23	18KB	6.69Sec
		20	25.24	17KB	4.82Sec	24.66	15KB	6.17Sec
		40	24.40	14KB	4.20Sec	23.98	13KB	5.46Sec
		60	23.92	13KB	4.02Sec	23.78	12KB	5.34Sec
		80	23.76	12KB	3.20Sec	23.73	12KB	4.37Sec
	0.2	10	25.53	17KB	4.91Sec	25.15	14KB	5.70Sec
		20	25.16	13KB	4.12Sec	24.59	12KB	5.22Sec
		40	24.33	10KB	3.48Sec	23.92	9KB	4.60Sec
		60	23.68	9KB	3.31Sec	23.72	9KB	4.49Sec
		80	23.72	9KB	2.55Sec	23.68	9KB	3.65Sec

CONCLUSION

This analysis shows that compression size is easily tunable with wavelet threshold. Here compression increases with increase in the threshold value and quality factor with affordable PSNR. Compare to hard threshold soft threshold gives us better compression performance. Quantization factor is limited to 0.02 to 0.1 further increase will lead to abrupt image quality and it is difficult to tune up both compression and PSNR performance by a single threshold value and quantization factor. This method highly depends on the Dabouchious family. Decoder completely depends on encoders reduced array if it missed decoder couldn't work.

REFERENCES

1. Basha, S.M. and B.C. Jinaga, 2010. A Robust Image Compression Algorithm Using JPEG 2000 Standard with Golomb Rice Coding. International Journal of Computer Science and Network Security, 10(12): 26-33.
2. Hari Om Yadav and Hitesh Gupta, 2008. Image compression using 2D- Walsh Wavelet transform. International Journal of Emerging technology and Advanced Engineering, ISSN 2250-2459, ISO 9001:2008, 3(8).
3. Tisserand, E. and Y. Beeville, 1852. Original Structure for Walsh–Hadamard Transform on Sliding Window. Electronics Letters, 51(23): 1850-1852.
4. Strang, G. and T. Nguyen, Wavelets and Filter Banks. Wellesley-Cambridge press, Wellesley.
5. Bhoopathi, G. Arokiaswamy, 2011. Image Compression: An approach using Wavelet Transform and Modified FCM, International Journal of Computer Applications (0975 – 8887), 28(2).
6. Gonzalez, R.C. and R.E. Woods, Image Compression: Digital Image Processing: Second Edition. Pearson Education, Singapore, pp: 405-510.
7. Devid Solemon, 2007. Data compression: The complete reference, Fourth edition. Springer verlag, London Limited-2007.
8. Donoho, D.L., 1995. De-noising by soft-thresholding. IEEE Trans. Inform. Theory, 41: 613-627.

9. Antonini, M., M. Barlaud, P. Mathieu and I. Daubechies, Image coding using wavelet transform. IEEE Trans. On Image Processing, 1(2): 205-220.
10. Adams, M.D., 2001. The JPEG2000 still Image compression standard. ISO/IEC JTC1/SC29/WG1 (ITU-T SG8).
11. Rabbani, M. and R. Joshi, 2002. An overview of the JPEG2000 still image compression standard. Signal Processing: Image Communication, 17: 3-48.
12. Acharya, T. and P.S. Tsai, 2005. JPEG2000 Standard for Image Compression: Concepts, Algorithms and VLSI Architecture. New York: John Wiley & Sons.
13. Sayood, K., 2000. Introduction to Data compression: 2^{nd} edition. Academic press, Morgan Kaufman Publishers.