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Application of WDR Technique with different Wavelet Codecs for Image Compression

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Abstract

Storing and transferring the images data are raised in recent years due to requisiteness of transmission bandwidth for considerable storage capacity. Data compression method is proposed and applied in an attempt to convert data files into smaller files. The proposed and applied method is based on the Wavelet Difference Reduction (WDR) as considered the most efficient image coding method in recent years. Compression are done for three different Wavelet based Image techniques using WDR process. These techniques are implemented with different types of wavelet codecs. These are Daub2+2,2 Integer Wavelet transform, Daub5/3 integer to integer wavelet transform, and Daub9/7 Wavelet transform with level four. The used multimedia files are gray and color (Bmp) files of dimensions (512×512). The quality of the reconstructed images is calculated by using three performance parameters: Compression Ratio (CR), Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE) values. The experiments of comparing the compression outputs of both JPEG and JPEG2000 Standard are done. The results indicate that Daubechies9/7 wavelet filter give better results than other filters. And all the results are closer to the JPEG standard with good correlation.

Keywords: Wavelet Image Compression, CR, PSNR, MSE, and WDR.

تطبيق تقنية اختلاف الفرق (WDR) مع رموز مويجية لنظام ضغط الصور

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الخلاصة

ازدادت في السنوات الاخيره الحاجه الى تخزين وارسال بيانات الصور الكترونيا بسبب الحاجة إلى زيادة نطاق الإرسال لسعة التخزين الكبيرة. تم اقتراح طريقة ضغط البيانات وتطبيقها في محاولة لتحويل ملفات البيانات إلى ملفات أصغر.

تعتمد الطريقة المقترحة والمطبقة على اختلاف الفرق (WDR) التي تعتبر الطريقة الأكثر كفاءة لضغط الصور في السنوات الأخيرة. تمت عملية الضغط لثلاثة تقنيات مختلفة تعتمد على تقنية Wavelet باستخدام عملية اختلاف الفرق WDR. تم تنفيذ هذه التقنيات مع أنواع مختلفة من برامج الترميز المويجات. هذه هي Daub2 + 2، 2 Integer Wavelet transform، Daub5 / 3 integer to integer wavelet transform ، و Daub9 / 7 Wavelet transform باعتماد المستوى الرابع فقط. ان ملفات الوسائط

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المتعددة والمستخدمة هي ملفات الصور الرماديه والصور متعددة الألوان (Bmp) ذات الأبعاد (512 × 512). تم حساب جودة الصور التي تم إعادة بنائها باستخدام ثلاثة معاملات أداء نسبة الضغط (CR) وذروة الإشارة إلى نسبة الضوضاء (PSNR) وقيم متوسط مربع الخطأ (MSE). تم ايضا إجراء تجارب مقارنة مخرجات الضغط لكل من JPEG و JPEG2000 كصور مثالية معتمدة. تشير النتائج إلى أن طريقة المويجات Daubechies9 / 7 تعطي نتائج أفضل من المرشحات الأخرى. وان النتائج كانت جميعا أقرب إلى معيار JPEG المثالي مع ارتباط جيد.

1. Introduction

Reducing the bits wanted to reflect image with no changing the image or data quality is defined as compression process. These compressed data can lower the costs for storage; save storage capacity and bandwidth network [1]. The introduction of new services is demanding an even higher bandwidth with the expansion of the existing ones [2]. The data in the form of graphics, audio, video and image have to be compressed during the transmission process. The real image can be reconstructed from the compressed image [3]. Wavelet transforms and the compression algorithms have been widely studied and used in the earlier days [1].

The applying coding algorithms for still images depend on wavelet transform with the embedded zero-tree wavelet (EZW) algorithm, the wavelet difference reduction (WDR) algorithm and the division in algorithm of hierarchical trees (SPIHT) [4 and 5]. The results are compared and it is identified that WDR provides better results [5, 6, and 7].

The use of wavelet filter can make an important difference in performance for the selected compression algorithm, The Antonini 9/7 filter represents a good trade-off between filter length and PSNR; it has become nearly ubiquitous for compression with biorthogonal wavelets and tends to have visually pleasing smoothing of quantization error. In this paper, three wavelets are selected and they are applied to the various images. The wavelets are Daub 9/7, Daub 5/3, and Daub 2+2,2 wavelet transform [8].

The WDR algorithm joins run-length coding of the map with the run length symbols to show an embedded image coder. The zero tree data structure in both SPIHT and WDR techniques is precluded and preserving the set partitioning and the embedding principles of lossless bit plane coding. Each coefficient in a decomposed wavelet pyramid instead of employing the zero trees is assigned a linear position index in the WDR algorithm and the result of the encoding can be arithmetically compressed [5]. The described procedure depends on the elementary arithmetic coding algorithm [9]. The adjective adaptively scanned indicates that the algorithm to modify the used scanning order by WDR to get good performance [10]. The goal of the proposed compression system of images is lowering the redundancy and to store images or data in a suitable form. Therefore, the objectives of such system are to get rid of the storage as possible, and the reconstructed image is in a good quality. The organization of the paper is as follows. In Section 2, the WDR algorithm is discussed briefly. The results are discussed in Section 3. While, the performance evaluation of the two algorithms are discussed in Section 4 and the conclusion in section 5.

2. Related Work

A number of recent attempts are proposed to apply several typical methods for image compression

- Li and Wang, 2010, [5] studied underwater color image coding method using wavelet-based method to improve the WDR algorithm. They conclude that their algorithm is better than both WDR and SPIHT at very low bit rate in terms of compression efficiency and coding time, though for natural images it has similar performance with WDR and SPIHT.
- Raja and Suruliandi, 2011, [8] discussed the Image Compression using WDR & ASWDR methods with variable Wavelet Codecs and implemented various kinds of wavelet codecs. , they were applied two types of Wavelet transforms on the images before compression , DD 2+2,2 Integer and Daub 9/7. The quality of the reconstructed images is calculated by using three performance parameters PSNR, MSE and SNE values. The images yield high PSNR values and low MSE values.
- Ali Khan, et al., 2014, [4] discussed the Wavelet Image Compression using Encoder and decoder methods that are based on certain algorithms to minimize the number of memory. An associate

algorithmic rule which minimizes PSNR is delineated and it is embedded, called Rate distortion Optimized Embedding. Due to de-correlation property DWT has gained so much popularity .

- Hussaina, et al., 2018, [2] Surveyed in Lossless and Lossy algorithms to discuss the Image Compression. They concluded that in spite of the networks bandwidth has been continuously increased, introducing new services and the expansion of the existing ones need an even higher bandwidth.

3. Materials and Methods

3.1 The proposed system method

The proposed system structure flowchart is shown in Figure-1. The operation flowchart is started by selecting a suitable color and scale images. The next step represents the application of variable filters of the wavelet transforms. Then, some quantization processes are performed to show the elements of big set in terms of smaller set to lower the number of bits necessary to indicate all possible values of mapping outputs to fewer bits.

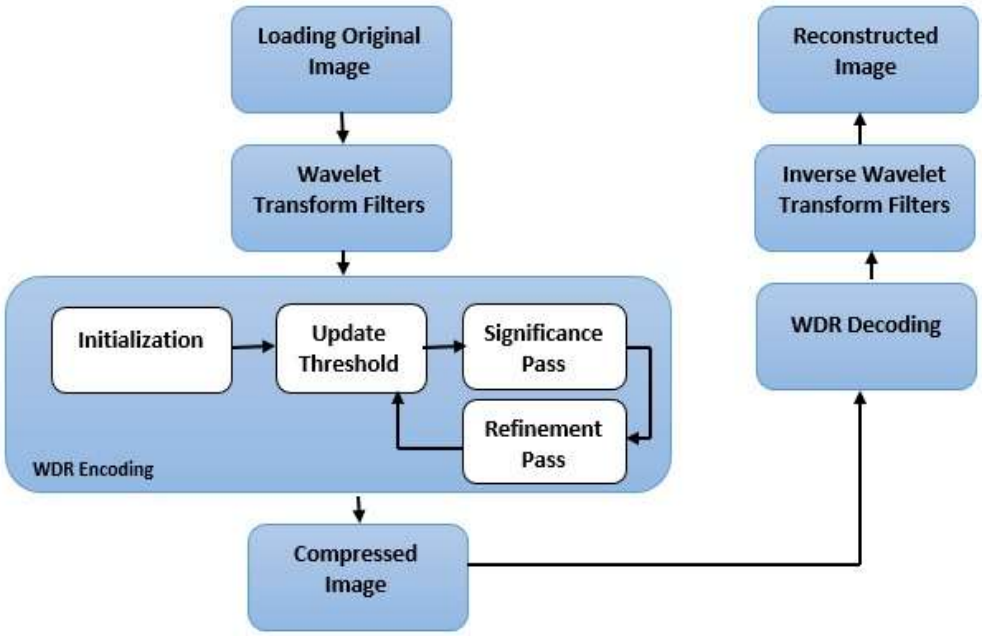

Figure 1-The proposed image compression system

3.1.1 WDR Algorithm

The position location of significant coefficients is the only implicitly of the defects of SPIHT. Therefore, it is difficult to perform operations like region chosen on compressed data that rely on the exact position of transform values. To increase resolution of the selecting portion of a compressed image, known as region of interest (ROI), is possible with the Wavelet Difference Reduction (WDR) algorithm [10,11and 12]. In WDR, the result of the important pass consists of values signs along with sequences of bits which describe the locations of these values.

Mainly five steps compose the WDR which are:

a. Initialization: The scan order should first be done. Scan order is a one-to-one and onto mapping $\tilde{F}_{i,j} = X_k$, for k=1, 2,… ,P between the wavelet coefficient and a linear ordering(X_k) for an image with P pixels. The zigzag scan order is through subbands from higher to lower levels. For coefficients in subbands‹ row-based scanning is applied in the horizontal subbands‹ columnbased scanning is practiced in the vertical subbands. As the scanning order is done, an initial threshold T_0 is selected so that the transform values satisfy $|X_m| < T_0$ and at least one transform value satisfies $|X_m| >= T_0 / 2$.

b. Update threshold: Let $T_k = T_{k-1} / 2$.

c. Significance pass: The transform values are greater than or equal to the threshold value then they are deemed significant and their index values are encoded by applying the difference reduction method that consists of a binary encoding to go from the index of the last important value to the index of the

current significant value [10, 11 and 12]. The results include the signs of significant values along with sequences of bits، created by difference reduction.

d. Refinement pass: It creates the refined bits via the standard bit-plane quantization method similar to the refinement process in SPHIT method [3].

e. Repeat steps: (b) through (d) until the bit budget is reached.

3.1.2 The Dataset

The images Baboon, Fruits, Peppers, Lena, Cameraman and Boat are applied for the tests with dimensions of (512*512). The original bmp images are shown in Figure-2. The results of tests are used to get the Peak Signal to Noise Ratio (PSNR) amounts, the compression ratio (CR) and the Mean Square Error (MSE) values from the reconstructed images.

a. Color Baboon.bmp

b. Color Fruits.bmp

c. Color Peppers.bmp

d. Color Lena.bmp

e. Gray Cameraman.bmp

f. Gray Boat.bmp

Figure 2-The Dataset

4. Results and Discussion

Using visual basic programing the WDR technique is implemented with level four of different wavelet transforms types on each image, Daub 9/7, Daub 5/3, and Daub 2+2,2 and efficiency parameters are calculated and shown in Tables-(1,2, and 3) [13]. To be compared with some of related work and with the standard JPEG2000 and JPEG with their qualities, see Table-4 [13].The efficiency parameters are:

A. Mean Square Error (MSE)

The image quality is measured in MSE. The more value of MSE resulting in bad quality. MSE is defined as follow to [8]:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

Where:

m is the image height.

n is the image width.

I(i, j) is original image.

K(i, j) is the reconstructed image.

B. Peak signal to noise ratio (PSNR)

The low value of PSNR [11] indicates the poor image quality. In general, a better reconstructed image is one with small MSE and high PSNR.. The PSNR is defined as[8]:

$$PSNR = 10log_{10}(\frac{MAX^2}{MSE})$$

Where MAX is the maximum possible pixel value of the image.

C. Compression Ratio (CR)

It is the ratio of original image bit stream to compressed image bit stream[8]:

$$CR = \frac{Total\ number\ of\ bits\ in\ original\ image}{Total\ number\ of\ bits\ in\ compresses\ image}$$

Table 1-CR,PSNR, & MSE Values for Proposed WDR Technique with Daub5/3 wavelet transform

	Image 512×512	CR	PSNR	MSE
Color Image	Baboon	10.003	24.46	232.32
	Fruits	10.003	37.15	12.52
	Peppers	10.003	37.26	12.21
	Lena	10.003	36.34	15.1
Gray Images	Cameraman	10.003	50.01	1
	Boat	10.003	39.88	6.67

Table 2-CR,PSNR, & MSE Values for Proposed WDR Technique with Daub9/7 wavelet transform

	Image 512×512	CR	PSNR	MSE
Color Images	Baboon	10.003	25.24	194.24
	Fruits	10.003	35.63	17.76
	Peppers	10.003	40.85	5.34
	Lena	10.005	36.97	13.04
Gray Images	Cameraman	10.6915	53.02	0.32
	Boat	10.005	41.37	4.73

Table 3-CR,PSNR, & MSE Values for Proposed WDR Technique with Daub2+2,2 wavelet transform

	Color Image 512×512	CR	PSNR	MSE
Color Images	Baboon	10.003	24.45	232.95
	Fruits	10.003	37.1	12.81
	Peppers	10.003	37.3	12.11
	Lena	10.005	36.37	14.97
Gray Images	Cameraman	10.003	50.23	1
	Boat	10.003	40.02	6.46

Table 4-CR,PSNR, & MSE Values for standard JPEG2000 and JPEG

	Image 512×512	JPEG 2000			JPEG Quality	JPEG		
		CR	MSE	PSNR		CR	MSE	PSNR
Color Images	Baboon	10.01	115.91	27.48	55%	10.09	174.4	25.714
	Fruits	9.98	6.44	40.04	85%	10.37	13.1	36.95
	Peppers	10.01	1.475	46.44	85%	11.08	3.74	42.392
	Lena	10	5.67	40.58	90%	9.8	9.26	38.46
Gray Images	Cameraman	10	1	50.44	93%	10.6	1	49.32
	Boat	10	2.72	43.78	83%	10	8.4	38.86

4.1 General Comparison

The results show that the CR is stayed closer in all wavelet kinds with the standard JPEG2000 and JPEG that give a good results.

The heighest PSNR of the color images is in the Peppers in all kinds of wavelet transform but the Daub9/7 wavelet transform shows that it is the closest one to the standard JPEG2000 and JPEG. While in the gray image the Cameraman has the heighest results of PSNR in all wavelet tranform types and also the Daub9/7 shows that it is the closer one to the standard JPEG2000 and JPEG (Figure-3). The lowest MSE value is shown in Peppers color image in all wavelet types and the lowest is in the Daub9/7 wavelet transform which is the closest one to the standard JPEG2000 and JPEG. While in the gray image the Cameraman image has the lowest MSE in all wavelet types and the Daub9/7 is also the closer to the standard JPEG2000 and JPEG(Figure-4). In conclusion, the Daub9/7 wavelet transform is closest to the JPEG more than to the JPEG2000 for all data set. The results are inagreement with Raja and Suruliand, [8] findings that this research results show higher in PSNR and the same in MSE in all mutual images and mutual wavelet types [8].

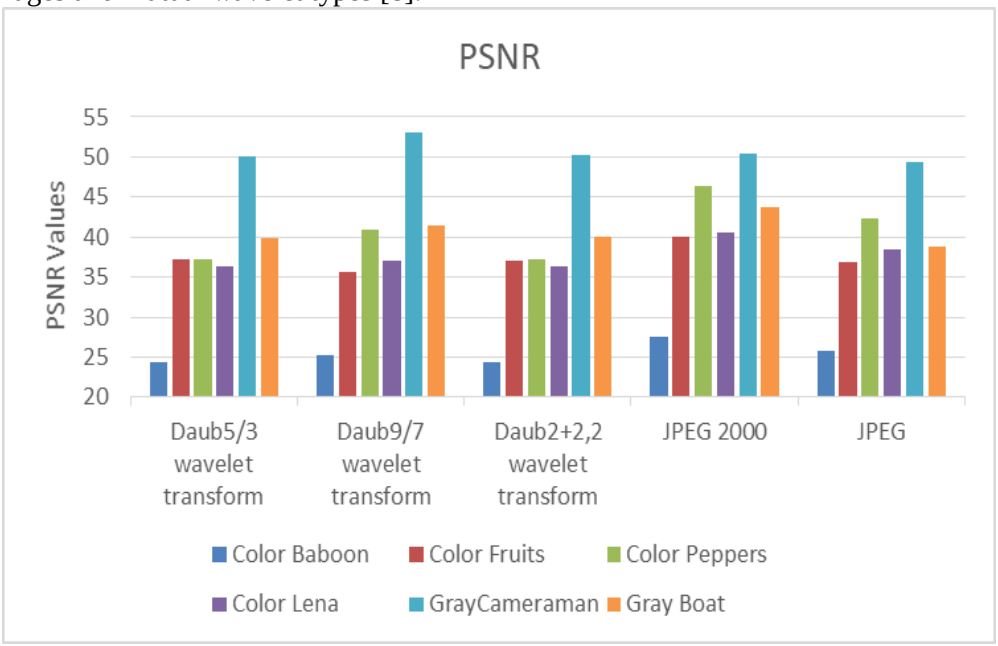

Figure 3-PSNR values for WDR compression with Daub 9/7, Daub 5/3, and Daub 2+2,2 wavelet transform

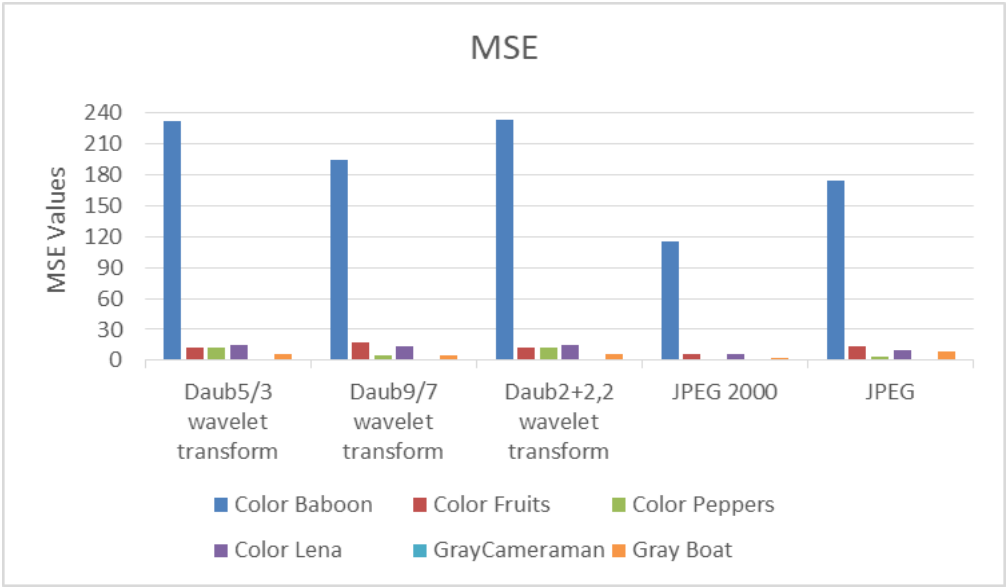

Figure 4-MSE values for WDR compression with Daub 9/7, Daub 5/3, and Daub 2+2,2 wavelet transform

5. Conclusion

The effects of different wavelet filter orders, number of decompositions, image contents and compression ratios were examined. The results of three wavelet types Daub9/7, Daub5/3, and Daub2+2,2 techniques on WDR were compared by applying the efficiency parameters PSNR, MSE and CR values from the reconstructed image. The WDR method is good in terms of the performance parameters and coding time compared with the standard JPEG and JPEG2000 images. It is identified that the PSNR values from the reconstructed images by using the Daub9/7 wavelet transform shows that it is the highest values of PSNR and the lowest values in MSE taking into consideration the images quality and features. The CR is closer and the same in all types of wavelet transform compared with the standard JPEG and JPEG2000 images. Finally, the findings of this research is closer to JPEG more than JPEG2000.

The experimental results show that the applied and proposed algorithm is easy to run, give good results and add new knowledge to other image compression systems that used, such as Matlab, Borland Delphi 7, visual studio with various versions, etc.

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