



IMAGE COMPRESSION ALGORITHMS BASED ON DISCRETE MULTIWAVELET TRANSFORM

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ABSTRACT

In the last two decades, the communication and Internet industry has seen a rapid development, which caused an increase needed to develop an efficient compression image algorithm to reduce the volumes of the information transmitted through the communication system. For this work, the discrete multi wavelet transform is used to build an efficient image compression algorithm. The proposed algorithm that is built by adopting Matlab, and it is tested by using two different images. The experimental results stated that the proposed algorithm has a good result with a very small loss of resolution when it is applied on the reconstructed images.

KEYWORD: Compression; image; Multi-wavelet; transform; Algorithm.

خوارزميات ضغط الصور بناءاً على تحويلة متعدد المويجات المنفصلة

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الملخص

في العقدين الماضيين، شهدت صناعة الاتصالات والإنترنت تطوراً سريعاً، والذي تسبب في زيادة الحاجة إلى تطوير كفاءة خوارزمية ضغط الصور لتقليل حجم المعلومات المرسل من خلال نظام الاتصالات. في هذا العمل، تم استخدام نظام تحويل متعدد المويجات المنفصلة لبناء خوارزمية عالية الكفاءة في ضغط الصور. الخوارزمية المقدمه والتي تم بناءها باستخدام برمجة الماتلاب وجرى الاختبار باستخدام صورتين مختلفتين خوارزمية ضغط الصور. نتائج الاختبار اثبتت ان الخوارزمية المقترحة اعطت نتائج جيدة جداً عند تطبيقها على الصور ووجود فقد قليل جداً في دقة الصورة التي اعيد بناؤها.

1. INTRODUCTION

Because of communication revolution, images are used as multimedia to transmit or encrypt other information, to deal with image meaning and with large amount of information needs a large space to storage it; this information appears as pixels (intensity) of image. The advantage of data compression was to reduce the space storage of image by representing it in fewest numbers of bits and using only the essential information that is needed to reconstruct the original image without any distortion. Often, the signal can process in time domain, other processing in frequency domains, for more efficient processing the combining between the time and frequency domain are perform, the processing and analyzing of the images are used some transformations such as multiwavelet transform.

The developing of wavelet transform is multiwavelet, but the scalar wavelet transform uses two or more scaling function and mother function to represent the signal (Liang et al., 1996). The implementation constraint wavelets do not satisfy the properties such as orthogonality, symmetry, short support, and higher approximation order (Sudha and Sudhakar, 2013). The famous filter of multiwavelet is the Geronimo, Hardin, and Massopust filter (GHM) that were used in this research. The basis of GHM filter offers combining of orthogonality symmetry and compacting support which is not found in the scalar wavelet transform (Liang et al., 1996).

2. MULTIWAVELETS

Multi wavelets are defined as a new class of wavelets with scaling functions (Sudha and Sudhakar, 2013; Jayanthi and Hazrathaiah, 2014). The idea of Multiwavelet originates from the generalization of scalar wavelets. Instead of one scaling and one wavelet function, multiple scaling and multiple wave-let functions are used. The initialization phase of the multiwavelet decomposition algorithm has been revealed to be crucial and strongly dependent upon the chosen multi-scaling basis (Cotronei et al., 2000).

This leads to more degree of freedom in constructing Multiwavelets. Therefore, opposed to scalar wavelets, properties such as orthogonality, symmetry, higher order of vanishing moments, compacting support can be gathered simultaneously in Multiwavelets (Selesnick, 1998).

There are four remarkable properties of the Geronimo-Hardin-Massopust scaling functions (Strela et al., 1999):

- 1- They has a short support for each function (the intervals $[0; 1]$ and $[0; 2]$).
- 2- Both scaling functions are symmetric.

- 3- All integer translates of the scaling functions are orthogonal.
- 4- The system has a second order of approximation (locally constant and locally linear functions are in V_0).

Multiwavelets were also based upon multiresolution analyses (MRA). MRA using comprises of one scaling function $\Phi(t)$, and one wavelet function $w(t)$, whereas a multiwavelets possess many number of scaling functions under one vector (Sudha and Sudhakar, 2013; Bhatnagar et al., 2015).

The scaling functions Φ_1 and Φ_2 are symmetric (linear phase), and they have a short support (two intervals or less). The coefficients of Multiwavelets are 2×2 matrix. It retains the orthogonality of the Multiwavelets. The incoming signal is a scalar type, and it is converted to a vector type by using pre-filter (Mahmoud et al., 2010).

The vector image is applied in discrete time filtering of discrete Multiwavelet transform to down sampled (decimated) by 2 to get high pass filter coefficients (c_k) and low pass filter coefficient (d_k) coefficients. This is the two-band analysis bank. A perfect reconstruction synthesis bank recovers the image from the two down sampled outputs as shown in Fig. 1. The sub-bands of a single level Multiwavelet decom-position is shown in Fig. 2. It has 16 sub-bands of an image (Strela et al., 1999; Bhatnagar et al., 2015).

Multiwavelets are characterized with several scaling functions and associated wavelet functions as given in Equations (1) and (2), respectively.

$$\Phi(t) = \sum c_k(2t - k) \quad (1)$$

$$W(t) = \sum d_k(2t - k) \quad (2)$$

Where $\Phi(t)$ is a multi-scaling function, $W(t)$ is a Multi-wavelet function. A multi filter has two or more low pass filters (Selesnick, 1998).

Multiwavelet system can simultaneously provide a perfect reconstruction while preserving length due to orthogonality of filters, good performance at the boundaries (via linear-phase symmetry), and a high order of approximation (vanishing moments) (Bhatnagar et al., 2015; Mahmoud et al., 2010).

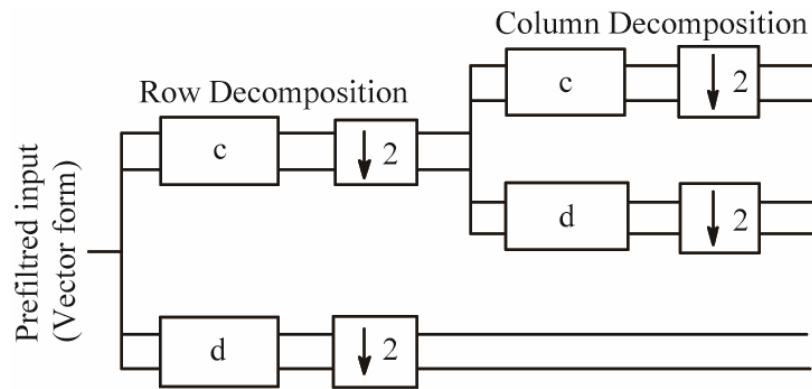


Fig. 1. A multi-filter bank with low pass filter iterated once.

L_1L_1	L_1L_2	L_1H_1	L_1H_2
L_2L_1	L_2L_2	L_2H_1	L_2H_2
H_1L_1	H_1L_2	H_1H_1	H_1H_2
H_2L_1	H_2L_2	H_2H_1	H_2H_2

Fig. 2. Image sub-bands after one level of Multiwavelet decomposition.

3. PROPOSED COMPRESSION ALGORITHM

The general encoding architecture of image compression system is shown in Fig. 3.

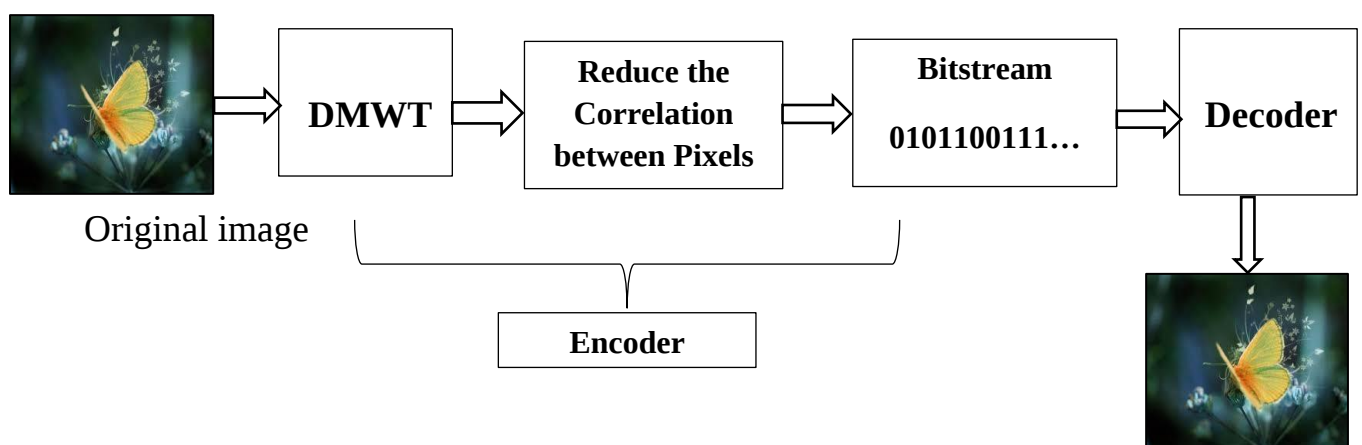


Fig. 3. The image compression system Original.

The correlation between one pixel and its neighbor pixels is very high, or you can say that the values of one pixel and its adjacent pixels are very similar. Once the correlation between the

pixels is reduced, then you can take the advantage of the statistical characteristics and the variable length coding theory to reduce the storage quantity. This is the most important part of the image compression algorithm; which consists of four steps:

- 5- Read the original image and convert it to the gray image.
- 6- Applying the wanted transform that is the discrete multiwavelet transform.
- 7- Reduce the correlation between pixels in different percentage values.
- 8- Convert the encoding pixels to the binary bits and transmit it to the channel.

In the other sides of the channel these steps are performed:

- 1- The binary bits are converted to the decimal values.
- 2- The decimal values are decoded by applying the inverse encoder transforms.
- 3- Extract the original image.

4. THE EXPERIMENT RESULTS AND DISCUSSION

Two pictures were taken as a case study as shown in Fig. 4, were applied compression operation using Discrete Multiwavelet Transform (DMWT). As shown in Fig. 5 in 10%, 25%, 50%, and 75% compressions values are applied on the image. To study the properties of the transform and its activity in compression, the comparing between the results are performed. The images in Figs. 6 and 7, Tables 1 and 2 show the results based on the measurement of the percentage signal strength to noise ratio (PSNR) and the root mean square errors (RMS).



Fig. 4. The original images of algorithm.

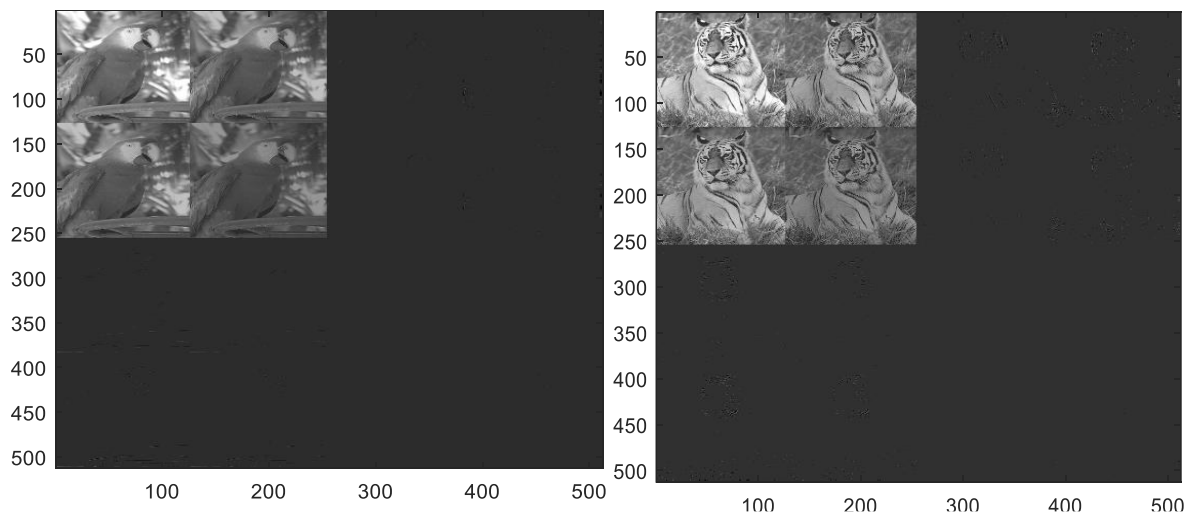


Fig. 5. Multilevel decomposition images.



a-original color image



b- original color image



c- 10% compression



d-25% compression



e-50% compression



f -75% compression

Fig. 6. Applying the DMWT compression on the first image.

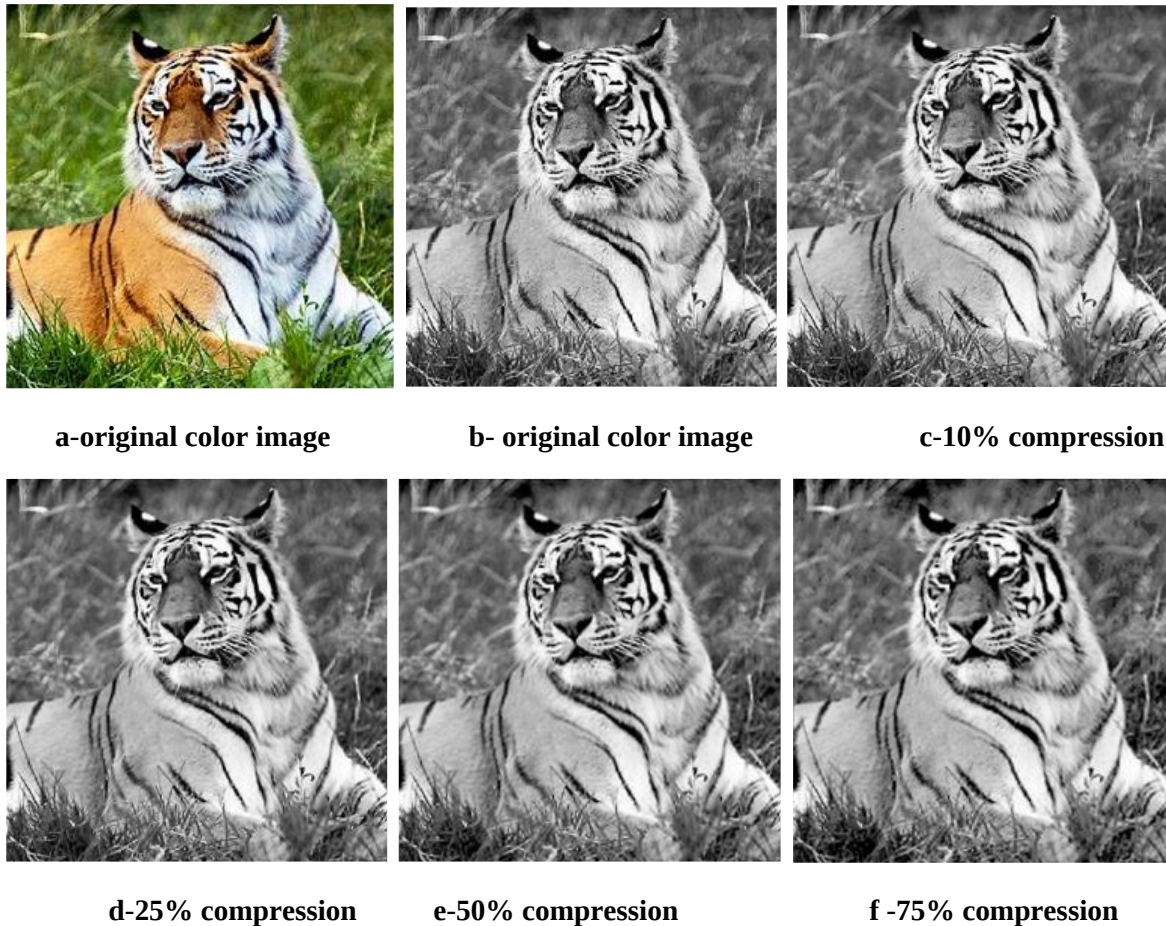


Fig. 7. Applying the DMWT compression on the second image.

Table 1. The results values of DMWT compression of the first image

	10% comp.	25% comp.	50%comp.	75%comp.
PSNR (dB)	92.38	83.16	74.39	60.22
RMS(bit)	2.510	3.980	6.182	12.55

Table 2. The results values of DMWT compression of the third image

	10% comp.	25% comp.	50%comp.	75%comp.
PSNR(dB)	83.96	70.20	62.55	58.33
RMS(bit)	3.820	7.600	11.17	13.70

The most important part of the image compression is reducing the storage quantity of the pixels of variable length in coding theory. In this paper, the taken coding transform is the discrete multiwavelet transform and applied on (256*256-png) image to study the properties of this

transform in the compression technique. The multiwavelets considered here are Geronimo-Hardin-Massopust (GHM), and the De-composition leads to a good energy compaction by measuring the PSNR from these equations.

$$PSNR = 20 \log \left(\frac{2^n - 1}{\sqrt{MSE}} \right) dB \quad (3)$$

$$MSE = \frac{1}{N_y N_x} \sum_{j=1}^{N_y} \sum_{i=1}^{N_x} [f(i, j) - f'(i, j)]^2 \quad (4)$$

In this formula, $f(i, j)$ is the value of the pixel point (i, j) of the original image, $f'(i, j)$ is the value of the pixel point (i, j) of the reconstructed image, N_x and N_y are the numbers of rows and columns of the image respectively and n is the number of digits, and (MSE) is the mean square error between the data of the original image and the reconstructed image.

The ratio of compression is taken in different values such as (10, 25, 50, and 75) percentage, so that for every point of the PSNR and RMS values are determined as follows (92.38dB, 2.51 bits in the first image and 83.96dB, 3.82bits in the second image). In these examples images, note when the compression value is small, the value of PSNR is high and the RMS value is low.

5. CONCLUSION

This paper discusses the efficiency of multiwavelets on compression images. Multiwavelets have the capability of possessing properties, such as symmetry, short support, and orthogonality. These properties are taken to reduce the correlated pixels of image to reduce the storage quantities without any loss in the quality of images. It can be noted from the results that the PSNR reached to 92.38db for 10% compression, and the lowest value is 58.33db for 75% compression. Also the images can be extracted without distortion in all values of compression; this means that the transform was working well in compression and gave good results.

6. REFERENCES

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