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Retrieving Image from Noisy Version depending on Multiwavelet Soft-Thresholding with Smoothing Filter

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Abstract

In this paper, we describe a new method for image denoising. We analyze properties of the Multiwavelet coefficients of natural images. Also it suggests a method for computing the Multiwavelet transform using the 1st order approximation. This paper describes a simple and effective model for noise removal through suggesting a new technique for retrieving the image by allowing us to estimate it from the noisy image. The proposed algorithm depends on mixing both soft-thresholds with Mean filter and applying concurrently on noisy image by dividing into blocks of equal size (for concurrent processed to increase the performance of the enhancement process and to decease the time that is needed for implementation by applying the proposed algorithm on all four blocks concurrently) which are employed in order to remove the noise. The proposed method of image retrieving and smoothing outperforms the conventional methods that are used for image enhancement. The suggested algorithm and the evaluation test carried using Delphi V.5 package.

Introduction

Digital images are pronr to a variety of types of noise. Noise is the result of errors in the image acquisition process that result in pixel values that do not reflect the true intensities of the real scene. There are several ways that noise can be introduced into an image, depending on how the image is created . For example [1], if the image is scanned from a photograph made on film, the film grain is a source of noise. Noise can also be the result of damage to the film, or be introduced by the scanner itself. Also, if the image is acquired directly in a digital format, the mechanism for gathering the data (such as a CCD detector) can introduce noise, and electronic transmission of image data can introduce noise.

In practice, image denoising is used when you somehow obtain a noisy image, and you want to remove as many of the speckles from the image as possible, without removing or distorting any features in it. Both denoising and enhancement are important field in digital image processing. Transforms play a great role in this field since they offer a new representation for the data in which features to be processed become more distinct [2]. There are two powerful techniques to reduce the noise level in a signal:- Mean filtering and Multiwavelet Soft-Thresholding. Mean filtering is a linear procedure while Multiwavelet Soft-Thresholding is nonlinear. Classical versions of both methods tend to blur edges in images. We try to blend these two approaches in order to improve the performance. Our idea is to divide the input image (noisy version) into four blocks of equal size then apply Multiwavelet Soft-Thresholding for each distinct block and the result that achieved from this step will be enhanced by using Mean filter, then group the four distinct resultant blocks to get the final retrieval image. Multiwavelet transformation is directly applicable only to one-dimensional signals, but images are two-dimensional signals, so there must be a way to process them with a one-dimensional transform [1]. The next section will describe how to make this type of transformation to work with images.

Types of Thresholding and its Selection Rules:-

Thresholding is non-linear operation performed on the Multiwavelet coefficients of noisy signal [5]. It is widely used in noise reduction, signal and image compression or recognition [3]. This can be done by comparing the absolute value of the empirical Multiwavelet coefficients with a value called Threshold Value (***Thv***). It is clear that if the Multiwavelet coefficient is equal to or less than the threshold value, then one can not separate the signal from the noise. In this case, a good estimation for that Multiwavelet coefficient is zero. In the case of an empirical Multiwavelet coefficient is greater than the threshold value, then a natural estimation for this Multiwavelet coefficient is empirical Multiwavelet coefficient itself. This idea is called *Thresholding*.

2.1 ***Hard-Thresholding***:- Which can be computed by [5]:-

$$\hat{A}_k^j = T_h(G_k^j, Thv) = \begin{cases} G_k^j & \left|G_k^j\right| > Thv \\ 0 & \left|G_k^j\right| \le Thv \end{cases} \qquad \text{\_\_\_\_\_\_ (1)}$$

Where *Thv* is the threshold value or the gate value.

2.2 ***Soft-Thresholding***:- Can be computed as [8]:-

$$\hat{A}_k^j = T_h(G_k^j, Thv) = \begin{cases} Sign(G_k^j) \times \left|G_k^j\right| - Thv & \left|G_k^j\right| > Thv \\ 0 & \left|G_k^j\right| \le Thv \end{cases}$$

Where **: -**

$$Sign(G_k^j) = \begin{cases} +1 & G_k^j > 0 \\ 0 & G_k^j = 0 \\ -1 & G_k^j < 0 \end{cases} \qquad \text{\_\_\_\_\_\_ (2)}$$

The graphical representation for the two types of Thresholding (Hard and Soft Threshloding) is shown in figures (1 and 2 respectively).

Threshold Selection Rules:-

In Thresholding process, coefficients smaller than threshold value *Thv* are judged negligible, or noise other than signal. Hence, threshold value *Thv* controls the degree of noise rejection, but also of valid signal rejection. One hopes, to set thresholds which are small, but which are very likely to exceed every coefficient in case of a pure noise signal [3, 5]. Two rules are used to select threshold values as follows:-

- ✦ Select the threshold by estimating the standard deviation σ_z of the noise at each scale, and taking into account that the threshold values have to be different on each scale level. The thresholds in this case are calculated as $Thv = b\,\sigma_z$ where b is a parameter, typically between 2 and 4.
- ✦ The choice of the threshold is a very delicate and important statistical problem. A big threshold *Thv* leads to a large bias of the estimator. On the other hand, a small threshold increases the variance of the smoother. Donoho and Johnstone have proposed the following value of the suitable value of threshold:-

$$Thv = Sqrt\ (2\ \sigma_z^2\ \log_e(N)) \qquad \text{\_\_\_\_\_\_ (3)}$$

Where N **is the length of the input signal.**

A proposed algorithm for retrieving image from noisy version depending on Multiwavelet Soft-Thresholding with using equal size block divide with mean filte

In this section, new method is proposed for retrieving image from noisy version by dividing the noisy image into four equal size blocks and using Multiwavelet Soft-Thresholding then enhances the result through an enhancement filter of type mean filter which is applied two times on some parts of the processed image, as shown in the figure (2).The steps of the proposed method are as follows:-

1. Divide the input noisy image into four blocks of equal size, and then obtain the Multiwavelet transformation coefficients (G_k^j) for the four divided blocks concurrently.
2. Compute the threshold value (***Thv***) by equation (3) or any other one of the threshold selection rules mentioned in previous section (2.3) then filter the Multiwavelet transform coefficients (G_k^j) by equation (2) which is used to compute the Soft-Thresholding since the work of this research depends on the Soft- Thresholding type, then replace the Multiwavelet transform coefficients (G_k^j) by applying the sign function on it and multiply the result by the absolute value of the coefficients then subtract the value of ***Thv*** from the final result if the absolute value for Multiwavelet transform coefficients (G_k^j) is greater than the threshold value (***Thv***), else replace it with a zero value.
3. Apply enhancement approach on the high pass region for each resultant by using mean filter and leave the low-pass components as it is.
4. Inverse the Multiwavelet transform threshold coefficients $(\hat{A}_k^j)$ to retrieve the image, and smooth each resultant block by using mean filter, then group the resultant four

blocks with each other to form the denoised smoothing image which represents the final result from this algorithm.
Figure (3) shows the block diagram for this proposed algorithm.

System Implementation and Requirements

The system is designed by dividing into four main parts:-

1. Dividing the noisy image into four blocks, as shown in figure (4.A.1).
2. Multiwavelet transforms and it's inverse, as shown in figure (4.A.2 and 4.B.1).
3. Computing Soft-Thresholding values, as shown in figure (4.A.3).
4. Smoothing filter which is applied two times, as shown in figure (4.A.3 and 4.B.2).

By using the specified system requirements, figures (4.A and 4.B) will illustrate how the suggested algorithm has been work

Here is the table of values for comparing between the initial noisy image and the resultant final enhanced image to improve the efficiency of the proposed algorithm, note that the value of SNR (Signal to Noise Ratio) is computed using the following equation:-

$$SNR = 10 \log_{10} \left[\frac{\sum_{r=0}^{M-1} \sum_{c=0}^{N-1} \left(\hat{I}(r,c)\right)^2}{\sum_{r=0}^{M-1} \sum_{c=0}^{N-1} \left(X(r,c) - (r,c)\right)^2} \right] \quad \text{(4)}$$

Where:-

$\hat{I}(r,c)$ Represents the signal (The Denoised Image) with *r*-row of size equal to M and *c*-column of size equal to N.

$X(r,c)$ Represent the errors (The Noisy Image) with *r*-row of size equal to M and *c*-column of size equal to N.

Note that the large number for the value of SNR means we get a better image

Conclusions

This paper presents a new technique for image denoising through the use of Multiwavelet Soft-Thresholding. Using this method, image noise can be reduced effectively and little image detail is lost. Multiwavelet transform have a great and important role in image denoising and enhancement due to its multi-resolution analysis. It depends on the same principles of wavelet transform with different two-dimensional filters and with pre/post processing mechanisms. From the work in this paper, the following points are concluded:-

1. Dividing image into blocks of equal size not for improving the enhancement process but to improve the performance of the algorithm by reducing the time of processing. The purpose from dividing the image into four blocks of equal sizes is to concurrent processed in order to increase the performance of the enhancement process and to decease the time that is needed for implementation by applying the proposed algorithm on all four blocks concurrently (at the same time). This will led to reduce the time of implementation to a rate equal the number of blocks, i.e., if the image is divided into 16 blocks of equals size, the time needed to perform this algorithm is reduced to the number of blocks which is here 8 units of time.
2. By computing the value of SNR we can conclude that the value of SNR for the noisy image (Initial Noisy Image) is equal to 0.0783, this value is the same for each block after dividing process, while this value will be 3.0938 and the same for each block after applying the proposed algorithm. This will led to show that the value of SNR

3. could not be changed depending on dividing blocks and the proof for this is SNR still have the same value, but SNR will be changed after applying the algorithm and table (1) shows that.
4. Several papers and researches deal with wavelet transformation that is used in image denoising and compression due to the properties of this transform. These properties are orthogonality, compact support, linear phase, and high approximation/vanishing moments of the basis function, are found to be useful in image processing techniques. Unfortunately, the wavelets can never possess all the above mentioned properties simultaneously Multiwavelet possesses more than one scaling function offer the possibility of superior performance and high degree of freedom for image processing applications, compared with scalar wavelets. Multiwavelet can achieve better level of performance than scalar wavelets with similar computational complexity. Dealing with image denoising using Multiwavelet transform, gives an idea that Multiwavelet eliminates the noise from images better than using the wavelet transform.
5. There are two important parameters in Multiwavelet Thresholding denoising algorithm namely the threshold value (***Thv***) and the Multiwavelet basis. For the first parameter, it is found that the optimal threshold value can be computed as $b\sigma_z$, where b is a constant.

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Table (1):- Comparing between the results before and after applying the algorithm

	Initial Noisy Image	Block1	Block2	Block3	Block4	Final Enhanced Image
Size	H =256 W =256	H = 64 W = 64	H = 64 W = 64	H = 64 W = 64	H = 64 W = 64	H = 256 W = 256
SNR before applying algorithm	0.0783	0.0783	0.0783	0.0783	0.0783	
SNR after applying algorithm		3.0938	3.0938	3.0938	3.0938	3.0938
The difference between the results		The difference between the results can be comuted by 3.0938 - 0.0783 = 3.0155 (Three times of the denoising degree). That means the advantage of this algorithim is to get a greate value for SNR which leds to get better image.				
The Time needed for the processing		The same for all since these blocks are running concurrently (at the same time), so the time needed for implementation is reduced to the four times (the number of blocks) that is is needed when process the image without dividing.				

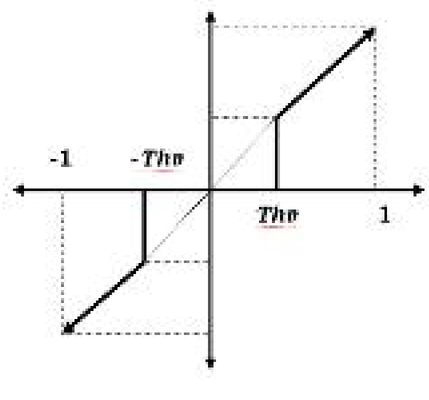

Fig. (1) Hard Thresholding

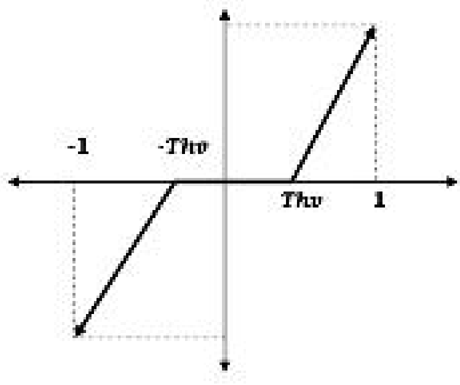

Fig. (2) Soft Thresholding

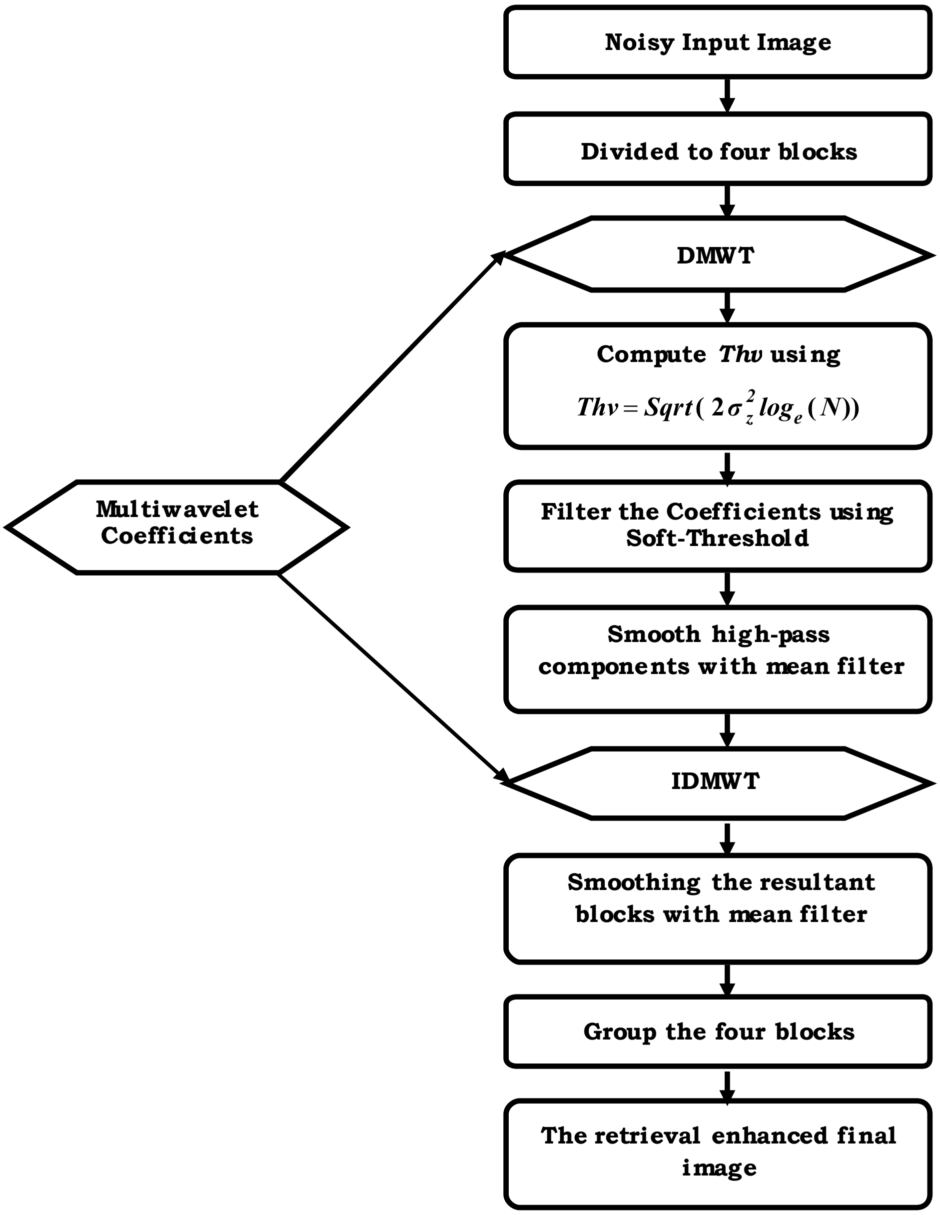

Fig. (3) A flow diagram for the proposed image retrieving method by using Multiwavelet Soft-Thresholding with enhancement mean filter

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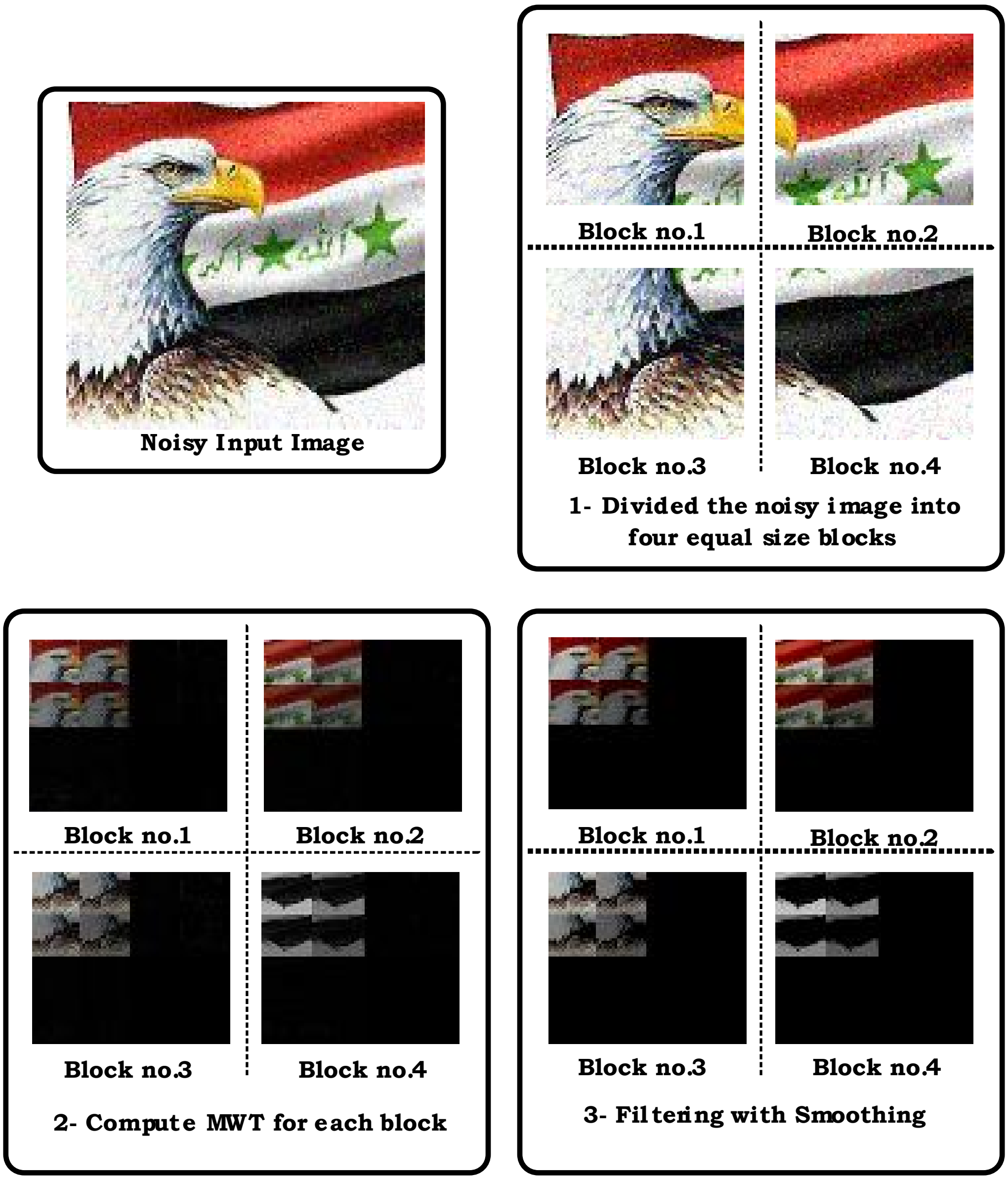

Fig. (4.A) A step by step implementation for image retrieving method by using Multiwavelet Soft-Thresholding with smoothing mean filter

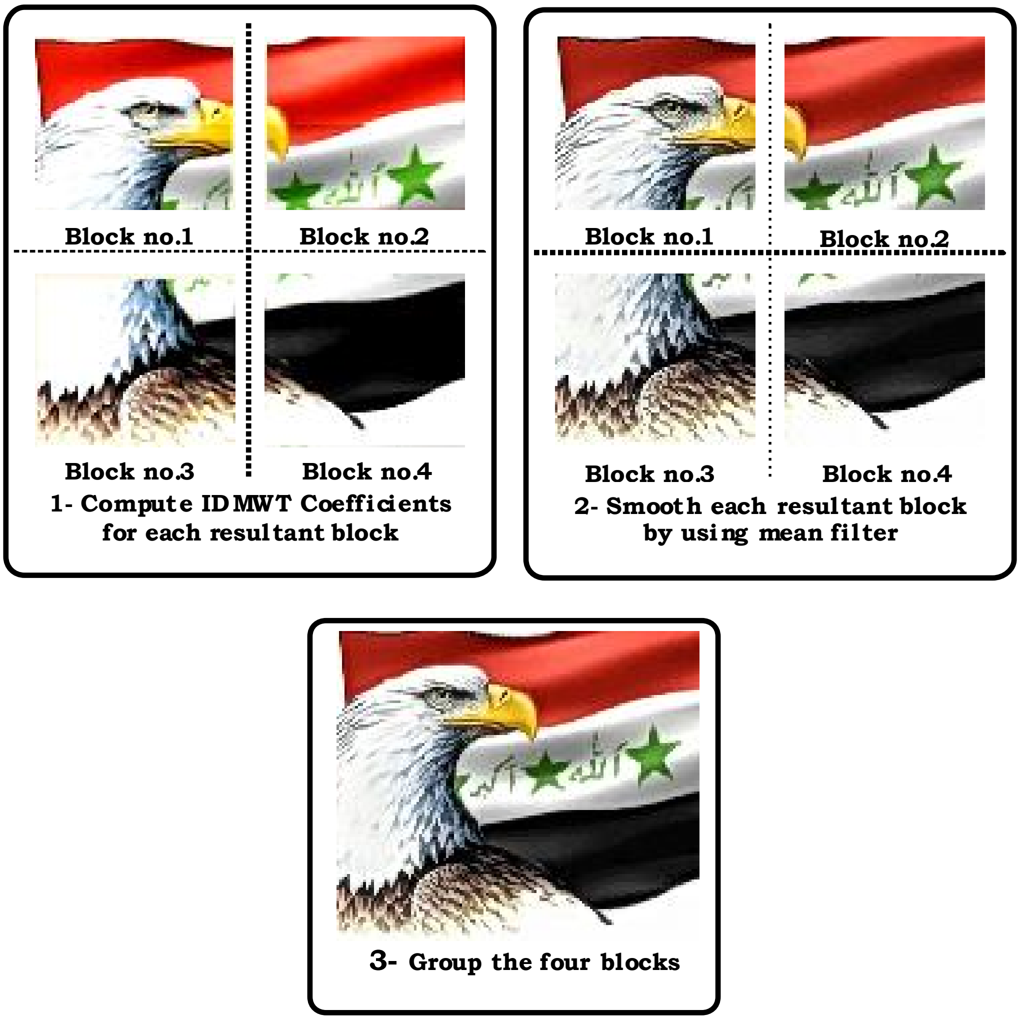

Fig. (4.B) **The reminder step by step implementation for image retrieving method by using Multiwavelet Soft-Thresholding with smoothing mean filter.**

استرجاع الصور من النسخة المشوهة باستخدام Soft-Thesholding مع تحويل متعدد المويجة

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الخلاصة

يقترح هذا البحث طريقة لاسترجاع وازالة التشويه من الصور الملونة وتحسينها من خلال استخدام تحويل متعدد المويجة (*Discrete Multiwavelet Transform*) عن طريق الاستفادة من الخصائص الممكن الحصول عليها من خلال تطبيق هذا النوع من التحويلات.

يقترح هذا البحث ايضاً طريقة لكيفية حساب نوع من انواع تحويلات متعدد المويجة الذي يعرف بالنظام التقريبي الاول (1st *Order Approximation*). ويوضح هذا البحث طريقة مبسطة وذا فاعلية في ازالة التشويه من الصور من خلال اقتراح تقنية جديدة لاسترجاع الصور. الخوارزمية التي تم اقتراحها في هذا البحث تعتمد على مزج كل من (*Soft-Thresholding*) مع (*Mean Filter*) بالاعتماد على تحويل متعدد المويجة (*Discrete Multiwavelet Transform* DMWT) اذ يتم تطبيقها بشكل متزامن على الصورة عن طريق تقسيم وتجزئة الصورة على اربعة اجزاء متساوية الاحجام (*Equal Size Block Divide*) وتتم معالجة كل جزء بشكل انفرادي ومتزامن مع الاجزاء الاخرى والغرض من هذا التقسيم هو لزيادة سرعة المعالجة في ازالة وتحسين الصور الملونة وبشكل متزامن لكل اجزاء الصورة. ان الطريقة المقترحة في عملية استرجاع وازالة التشويه والتحسين تفوق الطرائق التقليدية المستخدمة والمتعارف عليها في عمليات تحسين الصور الملونة.

تم تقييم الخوارزمية التي تم اقتراحها في هذا البحث من خلال استخدام لغة باسكال المرئية المعروفة بـ (Delphi V.5 Package) ذي الاصدار الخامس.