Image Denoising Improvement using Siny-Soft Wavelet Thresholding

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Abstract

The problem of image denoising plays an important role in the field of image processing due to the noise foundation in any life medium that will causing image corruption, the goal of the paper is to present a new proposed thresholding technique for image denoising. The aim of the work is to evaluate the new proposed thresholding method and make a comparison with other denoising methods in the recent literatures using some common performance measure. A wavelet based denoising algorithm is proposed to improve the image quality; different methods are listed for comparative study and evaluation. The procedure for wavelet based denoising method is to calculate the wavelet transformation for the noisy image, then thresholding the coefficients in the wavelet domain with new proposed thresholding and proper selected threshold other parameters. The evaluation process involved of suing PSNR as a performance metric among various introduced denoising methods. The proposed thresholding method has been implemented using Matlab simulation program for denoising image and improves its quality. The obtained results have confirmed the proposed thresholding method operability and permit for recommending the new proposed method for solving the problem of noisy image by improving its quality though the proposed method. The prospects for further research can involve the investigation for proposed method operability with signal and image applications and other life and practical problems.

Keywords

Softy-sine thresholding, image, wavelet, denoising.

1. Introduction

The field of image processing represents one of the more practical fields in medical, military and industrial application. Therefore for any process to be accurate and precise it is important to remove out the impurities and leave the original thing without disturbance. Denoising operation support the human being to filter out the desired image from the contamination image. Many researches deal with this issue to improve the quality of the denoised image. Recent years many techniques were proposed to enhance the image using different topologies and strategies [1]. Image quality can be improved through using wavelet based denoising method, in this method an image was decomposed in to sub bands and a proper thresholds matrices were created, after that the image was denoised by some thresholding method and threshold selection rule in order to get the best image as compared with the original noise free image [2]. Recent years, many methods for image denoising were proposed in the literatures, such as: GBFMT, WFRT, and ANLMNT [3].

The object of study is explained by considering that any image transferring operation through a noisy medium will corrupt the original image with some unrequired noise; the operation for removing noise from this corrupted image may take different scenarios and ways. The denoising process is evaluated using some performance index such as peak signal to noise ratio.

In this paper, it is required to apply a new proposed wavelet based thresholding method for denoising image and improve its PSNR over other traditional methods. The subject of study is the image denoising

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methods used in recent researches and a comparative study among them using some comment performance index. The purpose of the work is to improve the image quality using wavelet based denoising method with new proposed thresholding technique known as siny-soft wavelet thresholding.

2. Problem Statement

Through most of the image transportation operation the image will face some types of noise, so in order to keep the original image qualified, it is recommended to denoise the noisy image prior to impellent further processing on it, in order not to get bad results and conclusions.

So in this paper a new proposed thresholding method is implemented for image denoising based wavelet transformation in order to enhance the image quality.

3. Review of the Work

Recent years, many researches deal with new methods for signal and image denoising. Some researches for image denoising can be summarized as follows. Novel denoising method known as adaptive non local means with method for noise thresholding, such that image quality can be improved with about PSNR 33.8 dB [1].

Other researches in biomedical engineering deals with ultrasound rental images and use curvelet and contourlet transformations in order to reduce the noise from the corrupted image [2].

Wavelet based researches play an important rule in the image denoising, one of the recent paper proposed a self-adaptive hierarchical threshold algorithm and make a comparative study for it with a global threshold selection algorithm. Self-adaptive method shows a better performance due to tracking for noise level rate instantiously with threshold selection at each level [3].

Another authors proposed another techniques for noise reduction in image enhancement. Garrote, SCAD, mixed and FDR rules are some methods used in their papers for denoising images and signals. The results for their process are qualified using SNR and MSE performance measures [4].

Other comparative study for different wavelet based denoising algorithms was introduced by researchers with several thresholding techniques such as visushrink, sure shrink, Bayes shrink, and feature adaptive shrinkage. All these techniques are evaluated using PSNR as a quantitate performance index [5, 6].

Bivariate shrinkage rule is also proposed by researchers who proposed using the advantage of both types for dual tree and orthogonal wavelet transform in their complex form to improve the shrinkage model significantly [7], to define the criteria of multimedia colors [8, 9].

4. Materials and Methods

The core for any comparison study is the suitable selection for a common performance index and dimension for evaluated parameters. So in denoising methods PSNR and MSE represent the most popular performance measure in this field. When considering wavelet denoising technique for image quality enhancement, there are different threshold selection rules and various thresholding methods in the literature of wavelet analysis.

Although the wavelet image denoising procedure can be summarized by three steps:

1. Calculation for wavelet transform coefficient for the image with suitable wavelet mother function, decomposing level, and simple wavelet or wavelet packet tree technique.
2. Thresholding the coefficients using some of the thresholding method with proper selected threshold based on some statistical rules relating to the estimated noise level.
3. Reconstruct the denoised image using the threshold coefficients and the same used wavelet mother function and levels.

5. Experiments

In this work, at the beginning a simple comparison for various wavelet mother functions based denoising techniques was established and tabulated in Table 1. After considering these different wavelet mother functions, Biorthogonal 5.8 wavelet mother function showed the best results among the compared mother functions when using a peak signal to noise ratio PSNR as a popular performance index. In this experiment three values for the noise variance are examined which are 10, 20, and 30. Lena image is used as a test image with 256×256 dimensions, and additive white Gaussian noise adopted and added to the original signal in order to evaluate the proposed thresholding method.

Table 1
Comparison for various wavelet functions at different nose levels

Wavelet	Db6	Sym6	Coif6	Bior 5.8
σ		PSNR Value		
10	31.46	34.73	33.23	40.12
20	29.07	31.58	31.65	38.31
30	27.29	28.78	28.78	35.78

Then a proposed wavelet based denoising algorithm is evaluated using siny-soft thresholding with suitable selected threshold. The PSNR results for some denoising methods in literature are taken from corresponding researches and tabulated in Table 2 for further comparison with the proposed siny-soft thresholding.

In this paper, a new wavelet based thresholding method is suggested as shown in Fig. 1 in order to improve the quality for the image under test. The proposed method can considered as a manipulation for the classical soft thresholding method, after addition for sinusoidal signal in the region out of the dead zone yielding a new siny-soft thresholding function. In addition to that, two fine tuning coefficients are augmented in the proposed thresholding equation to control the value and scale for the sinusoidal peaks in the passband region.

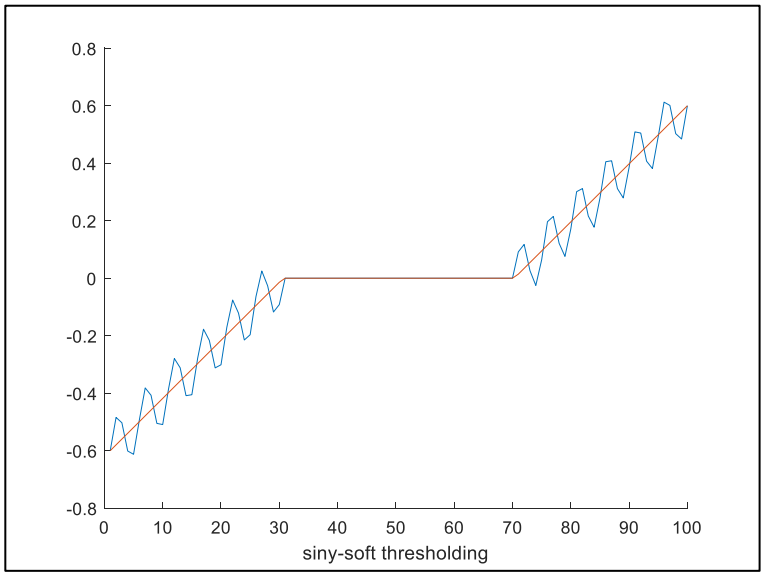

Figure 1: Proposed Siny-soft wavelet thresholding

Table 2
Comparison for various denoising methods with the proposed method

σ	10	20	30
Method		**PSNR Value**	
WT [1]	27.36	24.97	23.97
GBFMT [1]	33.07	29.23	27.19
WFRT [1]	33.23	28.94	26.71
ANLMNT [1]	33.80	30.34	28.11
Curvlet [2]	36.27	—	—
Contourlet [2]	39.84	—	—
Wavelet hierarchical threshold [3]	—	22.82	—
Wavelet global threshold [3]	—	21.40	—
Visu hard rule [4]	21.50	18.55	16.21
Visu soft rule [4]	18.60	15.95	14.23
Visu garrote rule [4]	20.10	16.91	15.6
Visu SCAD rule [4]	19.03	15.95	14.13
Visu Mixed rule [4]	23.12	19.23	17.01
Visu hard [5]	35.35	34.19	33.64
Visu soft [5]	34.45	33.71	33.27
B-M hard [5]	35.52	34.7	33.98
B-M soft [5]	34.64	34.24	33.85
Sime-soft [5]	36.29	34.31	33.10
SURE [5]	33.46	33.22	33.00
Bayes [5]	37.29	35.85	34.97
FAS [5]	36.78	34.73	33.45
Mean filtering [5]	36.07	33.63	32.13
Median filtering [5]	34.79	32.14	30.62
ST [6]	31.28	—	24.52
HT [6]	32.69	—	24.52
POAC [6]	30.09	—	24.53
Bayes shrink [7]	33.32	30.17	28.48
Adapt shrink [7]	31.07	—	—
HMT [7]	33.84	30.39	28.35
Lawmap [7]	34.10	30.89	29.05
Proposed in [10]	33.94	30.73	28.94
Complex [7]	35.34	32.40	30.54
Proposed in [11]	34.36	31.19	29.41
SI-adaptshr [7]	—	32.12	—
CHMT [7]	34.90	—	—
The system in [12]	34.96	31.72	—
The system in [13]	35.31	32.31	—
Our proposed work (siny-soft)	40.12	38.31	35.78

Here under some of mathematical models for the well-known thresholding method in corresponding with the proposed method:

Soft thresholding

$$Q_j = \begin{cases} [sign\,(W_j)(|W_j| - \lambda)] & |W_j| \geq \lambda \\ 0 & |W_j| < \lambda \end{cases} \quad (1)$$

Hard thresholding

$$Q_j = \begin{cases} W_j & |W_j| \geq \lambda \\ 0 & |W_j| < \lambda \end{cases} \quad (2)$$

Siny- Soft thresholding

$$Q_j = \begin{cases} [sign\,(W_j)(|W_j| - \lambda)] + asin(b\pi W_j) & |W_j| > \lambda \\ 0 & |W_j| \le \lambda \end{cases} \quad (3)$$

where Q_j is an output signal from wavelet thresholding at level j, W_j is an input signal to wavelet thresholding at level j, λ is a threshold.

6. Results

The simulation results for Matlab program demonstrates that wavelet based siny-soft thresholding technique improves the noise reduction and denoising performance in term of PSNR.

Referring to Table 1, three values for noise level are used to artificially corrupt the original image. Various wavelet mother functions are examined and compared using five decomposing level and proposed siny-soft thresholding with universal threshold.

From Table 1 biorthogonal 5.8 wavelet function is succeed as compared to other used functions, so further analysis for wavelet denoising will use this mother function in order to compare this new proposed method to other methods listed in the researches and literature.

Table 2 shows the summarized results for more than 11 references which were used image denoising with different methods and techniques. Three noise level are considered and PSNR values for about 30 experiment's by other researchers, our proposed method showed a good results for denoising for different noise level which are PSNR about 37.12, 35.31, and 33.78 dB for noise variance of 10, 20, and 30 respectively.

Results for denoising are also demonstrated by Fig. 2–5 which shows the enhancement for Lena image in three cases for various noise levels.

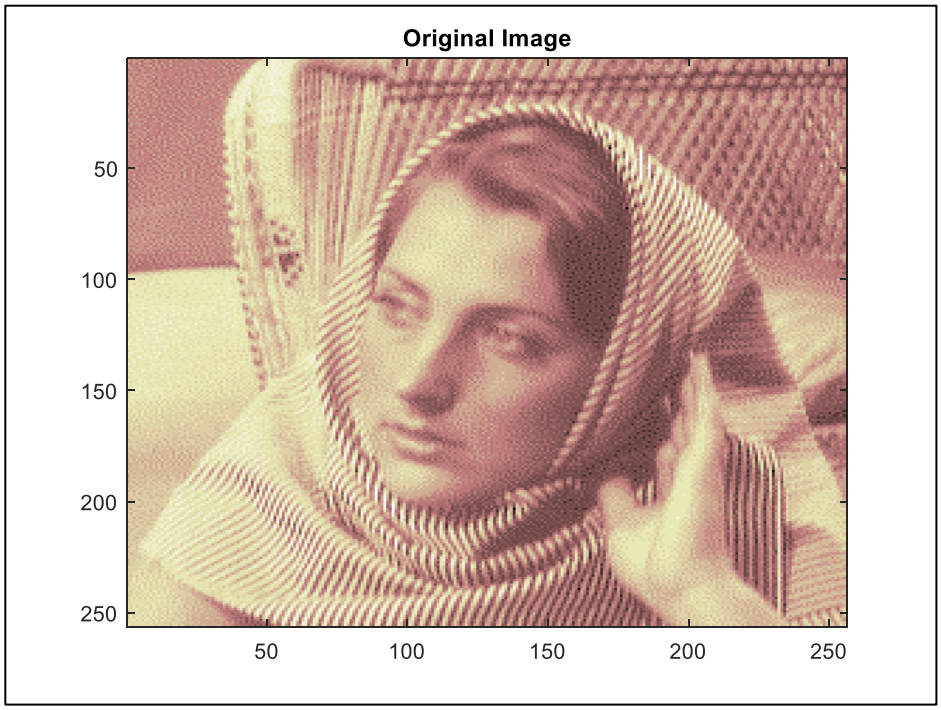

Figure 2: Original noiseless Lena image

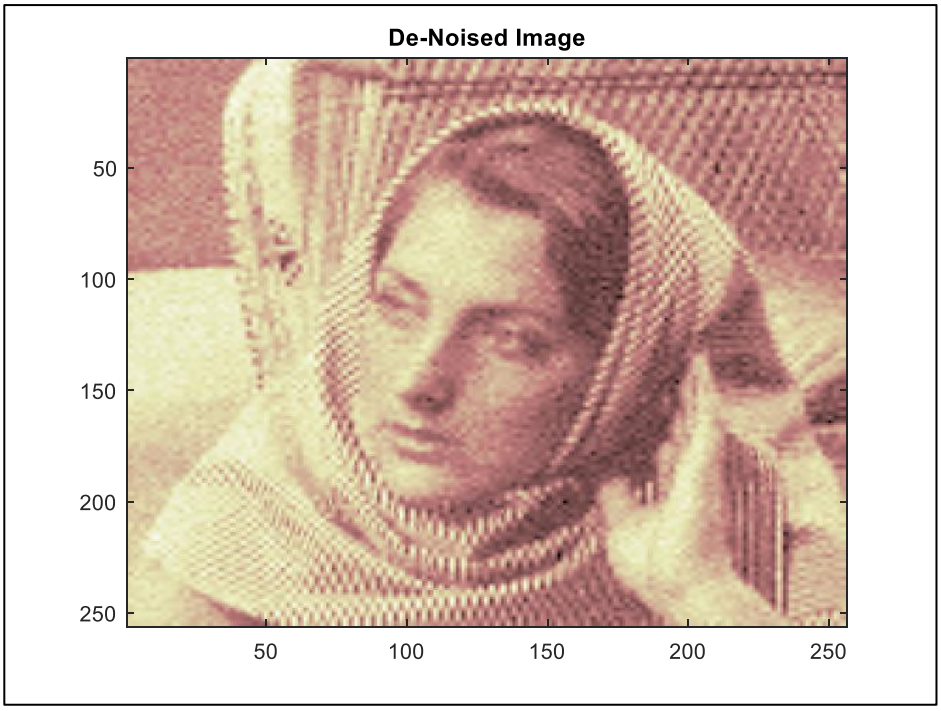

Figure 3: Denoised image using siny_soft for σ = 10 noise level

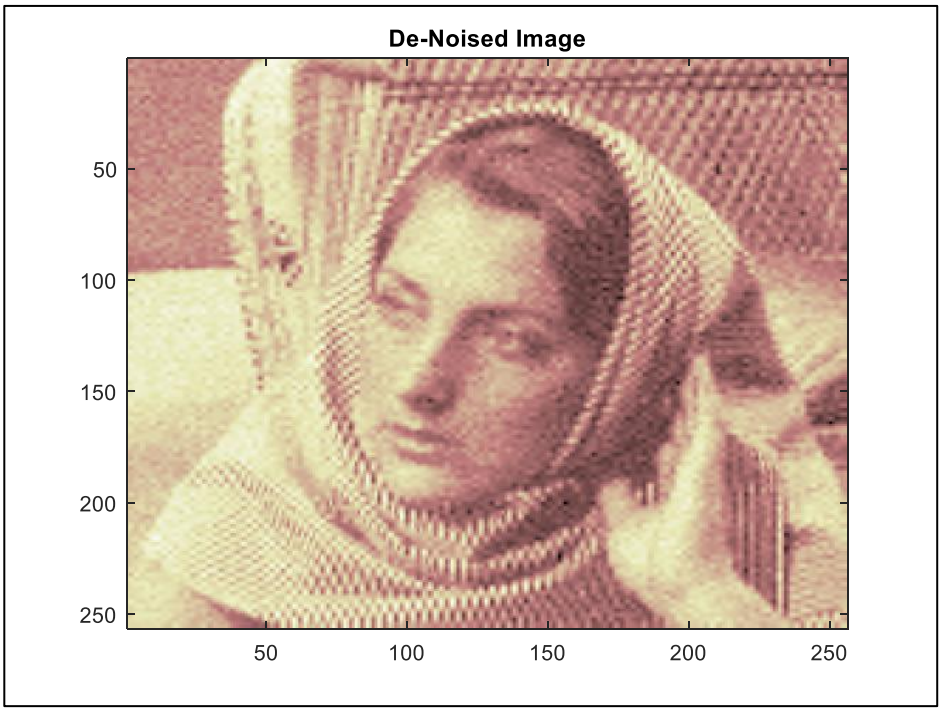

Figure 4: Denoised image using siny_soft for σ = 20 noise level

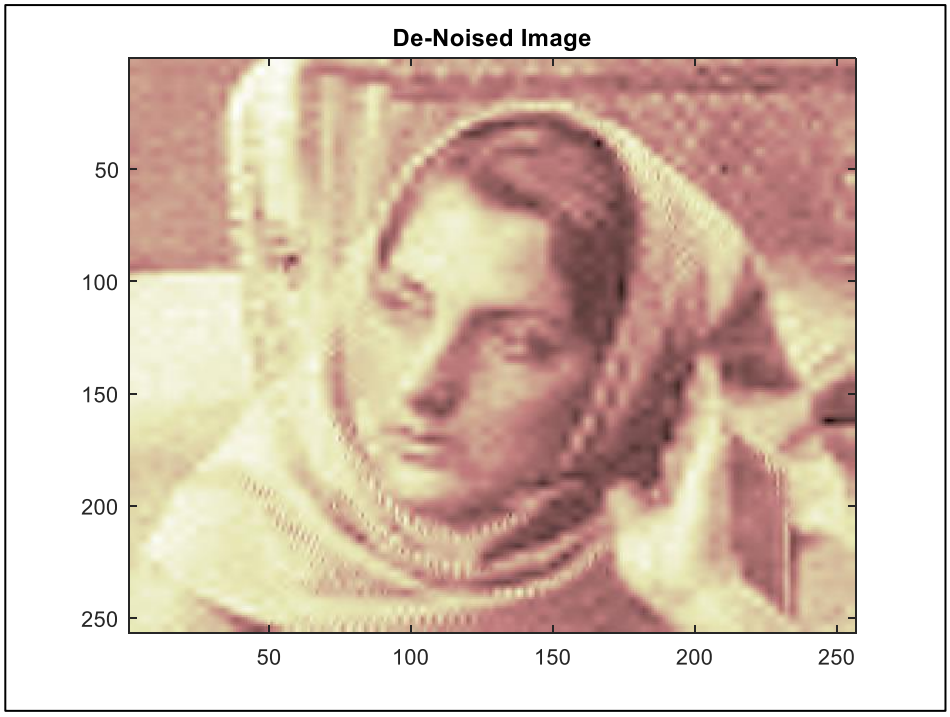

Figure 5: Denoised image using siny_soft for σ = 30 noise level

7. Discussion

Results for denoising methods showed many algorithms with different PSNR values, increasing noise level will degrade the performance of the denoising method as shown in Table 2 when comparing the results for the same used method at the same row , but with increasing noise level from σ =10 to 30.

It is recommended for further studies to examine different types for noise with various wavelet functions and decomposition level, also other performance metric such as MSE can be involved in conjugation with PSNR for further evaluation emphasis.

8. Conclusions

A new proposed wavelet based siny-soft thresholding is proposed in this work. Simulation results of the present method declared that the denoised images resulted from the proposed algorithm have an improved PSNR value when they are compared with other denoising method .so based on these result the proposed thresholding is suited for image denoising when images are corrupted with different types of noise. It is recommended to use the proposed thresholding for further studies of image or signal processing, especially for signal and image enhancement using wavelet based denoising or compression methods.

The scientific novelty for the conducted results is that the method for siny_soft thresholding is firstly proposed. The method shows good results as compared with traditional used methods for image denoising. Acceptable values for PSNR are achieved when using this new proposed method

The practical significance of the achieved results is that the new proposed method can be adopted deeply in image enhancement problems for further image processing applications. It is recommended to use wavelet based image denoising with siny_soft thresholding for improving PSNR of an image.

Prospects for further research are to study the possibility for extended the implementation of the proposed thresholding for further signal and image applications.

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