Comparison between Different Methods for Noise Cancellation in Medical Image

[1]**Azza M. Abd_elmegeed,** [2]**Mostafa Y. Makkey**

[1]Researcher, Department of Electrical Engineering, Assiut University, Assiut, Egypt
[2]Professor, Department of Electrical Engineering, Assiut University, Assiut, Egypt

Abstract - **In the medical community, doctors use different types of medical imaging to diagnose the disease. It is possible that these types lead to noise. The goal is to rid these types of noise of the appearance of the image clearly, to give the specialist proper medical examination. These types are Magnetic Resonance (MR), Computed Tomography (CT), Ultrasounds and X-Ray images. For measuring the denoised image quality we used: Peak to Signal noise (PSNR).This is to facilitate the medical community in obtaining the best results for the diagnosis, describing the disease and its treatment and deal with the patient clearly and comfortably.**

Keywords: Medicals Images; denoising; Speckle Noise; Rician Noise; Poisson Noise; Gaussian Noise; wavelet filter.

I. INTRODUCTION

Medical staff requires obtaining a best medical image quality to achieve efficient and fast examination, and with different types of medical imaging, these species are exposed to noise due to the configuration of the equipment used or environmental factors.

We have selected the most popular noise included in every medical method such as: Rician noise for MRI image, Poisson noise for X-ray image, AWGN for CT image and Speckle noise for Ultrasound image [6].

With other types of noise, the medical image may be exposed to it like salt & pepper and blurred noise [2]. There are many different types of filters used to eliminate this noise. This paper depends on four types of Wavelet filter [7]; are Coiflets, Biorthogonal, Daubechies and Symlets by measuring PSNR.

This paper is organized as follows: The second section provides an overview of the noise reduction methods used in medicine for: magnetic resonance imaging, ultrasound, computed tomography and x-ray data and the types of noise that each type of medical imaging may be exposed to. The third section describes a comparative study of the types of filters used in this article.

There are many algorithms for medical images noise removing such as median filter [1], Lee, Kuan, frost [5], wiener [8], Gaussian filter [8] and Wavelets Theory, We have been chosen four types of wavelets (the popular methods) for comparison.

1.1 MRI data

The MRI is exposed to some types of noise due to its composition such as Rician, Ricean distribution is the probability distribution of the amount of a circularly symmetric normal bivariate random variable, possibly with a non-zero (non-central) mean. Gaussian and Poisson and other factors like Salt & Pepper and blurred. [6, 8, 7]

1.2 X- Ray data

The X-Ray is exposed to some types of noise due to its composition such as Poisson; Poisson noise is a sort of noise that can be sculptured for the Poisson process. Shot noise in electronics arises from the discrete nature of the electrical charge also occurs in photon counting in optical devices, wherever shot noise is said to the particle nature of the light and Salt & Pepper due to other factors. [6]

1.3 CT data

The CT is exposed to some types of noise due to its composition such as Gaussian and Poisson; the most sources of Gaussian noise originate in digital images throughout acquisition. The sensor contains inherent noise because of its lighting level and temperature, and therefore the electronic circuits connected to the sensor inject their share of the electronic circuit noise and Poisson noise is a type of noise that can be sculptured for the Poisson process. Shot noise in electronics arises from the discrete nature of the electrical charge. Shot noise also occurs in photon counting in optical devices, wherever shot noise is said to the particle nature of the light and other factors like Salt & Pepper and blurred. [6,8]

1.4 Ultrasound data

The Ultrasound is exposed to some types of noise due to its composition such as speckle; Speckle is an inherently granular interference that is degraded by active radar,

synthetic aperture radar (SAR), medical ultrasound and optical tomography images and other factors like blurred. [6, 8,7]

II. COMPARATIVE STUDY OF DENOISING APPROACHES

The description of Selected Wavelet family is [9]:

Coiflets wavelets are supported compactly that have highest number of fade moments for both psi and phi for a given support width. Continuous and Discrete wavelet transform is possible with these.

The Biorthogonal Wavelets are supported compactly which symmetry and exact reconstruction is possible with FIR filters. The types are bior1.1, bior1.3, bior1.5, bior2.2, bior2.4 …etc. continuous and Discrete wavelet transforms are possible with these.

The Daubechies Wavelets are supported compactly that have highest number of fade moments. The types are db1, db2…db45. Continuous Wavelet Transform and Discrete wavelet transform is possible for these. These are not symmetrical. The length of the filter is 2N. The number of fade moments are N.

The Symlets Wavelets are supported compactly which have highest number of fade moments. The types are sym1, sym2, sym3, sym4 and sym5. Filter length is 2N. Continuous and Discrete wavelet transform is possible with these types of wavelets.

2.1 Comparison different image with different types of wavelets

This section describes the results obtained from the noise reduction process. This comparison is done using the waveform in level 7, depending on the size of the image, because the filter can be used at a lower level, and when used at a higher level, the image must be scaled to reach the level, by measuring PSNR. When the image is exposed to noise from the device as Speckle for Ultrasound, Gaussian for CT, Poisson for X-ray and Rician for MRI.

- The results for Coiflets Wavelets are given in Table 1. The coif2 gives better results for Ultrasound, CT, X-Ray and coif5 for MRI.
- The results for Biorthogonal wavelets are given in Table 2.Each type of filter differs with each type of imaging, but in general it is better for PSNR is bior4.4, bior6.8 for X-ray, bior1.1 for Ultrasound, bior2.6 for CT and bior2.8 for MRI.
- The results for Daubechies Wavelets are given in Table 3. The db3, db5 gives better results for CT, X-Ray, MRI and db4 for Ultrasound.

- The results for Symlets Wavelets are given in Table 4. The sym4 gives better results for MRI, CT, X-Ray and sym10 for Ultrasound.

Table 1: Comparison of PSNR for different medical image with coiflets wavelets

Wavelet	MRI (Rician noise=9)	X-ray (Poisson noise)	CT (Gaussian=0.2)	Ultrasound (speckle=0.2)
	PSNR	PSNR	PSNR	PSNR
Coif1	63.2294	73.3787	32.5556	44.1650
Coif2	63.4620	73.6522	32.6162	44.2097
Coif3	63.3935	73.4885	32.5214	44.1561
Coif4	63.5066	73.2350	32.5040	44.1701
Coif5	63.5855	73.3465	32.4913	44.1593

Table 2: Comparison of PSNR for different medical image with Biorthogonal wavelets

Wavelet	MRI (Rician noise=9)	X-ray (Poisson noise)	CT (Gaussian=0.2)	Ultrasound (speckle=0.2)
	PSNR	PSNR	PSNR	PSNR
Bior1.1	63.1087	72.4923	32.5084	44.2523
Bior1.3	63.3253	72.0180	32.6144	44.1656
Bior1.5	63.2625	71.5728	32.5981	44.1410
Bior2.2	63. 6138	72.4542	32.6234	44.1721
Bior2.4	63.8941	72.4277	32.5942	44.2109
Bior2.6	63.8647	72.3121	32.6517	44.1742
Bior2.8	64.0225	72.1511	32.6316	44.1931
Bior3.1	61.8486	68.2745	32.1835	44.2325
Bior3.3	63.1618	70.2794	32.4349	44.2238
Bior3.5	63.4652	70.5988	32.5581	44.1882
Bior3.7	63.5665	70.6494	32.6061	44.1719
Bior3.9	63.8882	70.7178	32.6396	44.1433
Bior4.4	63.4890	73.2623	32.6139	44.2212
Bior5.5	63.7334	72.6621	32.1885	44.1594
Bior6.8	63.6960	73.2643	32.5746	44.1715

Table 3: Comparison of PSNR for different medical image with Daubechies wavelets

Wavelet	MRI (Rician noise=9)	X-ray (Poisson noise)	CT (Gaussian=0.2)	Ultrasound (speckle=0.2)
	PSNR	PSNR	PSNR	PSNR
Db1	63.2389	72.4118	32.5297	44.1798
Db2	63.1882	73.4767	32.6602	44.1076
Db3	63.3189	73.6050	32.6257	44.1673
Db4	63.2309	73.5352	32.5779	44.2131
Db5	63.3747	73.6628	32.6631	44.1711
Db10	62.8201	73.5623	32.4350	44.1414
Db15	62.5153	73.2651	32.3727	44.1658
Db20	62.3576	73.2072	32.4175	44.1622
Db25	61.8771	72.8866	32.3823	44.1916
Db30	61.4602	72.7820	32.3031	44.1941
Db35	61.3465	72.5526	32.3442	44.1595
Db40	60.8149	72.4401	32.2608	44.2217
Db45	60.5367	72.3395	32.2867	44.2014

Table 4: Comparison of PSNR for different medical image with Symlets wavelets

Wavelet	MRI (Rician noise=9)	X-ray (Poisson noise)	CT (Gaussian=0.2)	Ultrasound (speckle=0.2)
	PSNR	PSNR	PSNR	PSNR
Sym2	63.1454	73.5643	32.6238	44.1764
Sym3	63.4150	73.6108	32.5652	44.1540
Sym4	63.7430	73.6704	32.6044	44.1631
Sym5	63.3792	73.5794	32.6022	44.1711
Sym10	63.3340	73.4993	32.5653	44.1969
Sym15	63.4718	73.1872	32.5042	44.1860
Sym20	63.4001	73.0655	32.4910	44.1790
Sym25	63.2387	72.7110	32.4963	44.1718
Sym30	63.4165	72.4263	32.5220	44.1369

2.2 Comparison one type of image with different types of noise

We mentioned that only one type of image may experience more than one type of noise as:

- Ultrasound (speckle noise and blurred noise).
- CT (salt & pepper, Poisson, Gaussian and blurred noise).
- X-ray (salt & pepper and poisson noise).
- MRI (Rician, poisson, Gaussian, salt & pepper and blurred noise).

🞣 The results for Coiflets Wavelets are;
❖ The coif2 gives better results for speckle noise for Ultrasound and all PSNRs are equal for blurred noise.
❖ The coif2 gives better results for Gaussian, poisson and salt & pepper for CT and coif5 for blurred noise.
❖ The coif2 gives better results for poisson noise for X-ray and coif5 for salt & pepper noise.
❖ The coif5 gives better results for Rician, Gaussian and salt & pepper for MRI, coif4 for poisson and coif4, 5 for blurred noise.

🞣 The results for Biorthogonal wavelets are;
❖ The bior1.1 gives better results for speckle for Ultrasound and all PSNRs are equal for blurred noise.
❖ The bior2.6 gives better results for Gaussian for CT, bior6.8 for salt & pepper and blurred noise and bior1.1 for poisson noise.
❖ The bior4.4and bior6.8 give better results for salt & pepper and poisson for X-ray.
❖ The bior2.8 gives better results for Rician for MRI, bior2.6 for poisson and bior6.8 for Gaussian, salt & pepper and blurred noise.

🞣 The results for Daubechies Wavelets are;
❖ The db4 gives better results for speckle for Ultrasound and all PSNRs are equal for blurred noise.
❖ The db3 and db5 give better results for Gaussian for CT, db3 for poisson and db30 for salt & pepper and blurred noise.
❖ The db3 and db5 give better results for poisson for X-ray and db30 for salt & pepper noise.
❖ The db3 and db5 give better results for Rician for MRI, db5 for poisson,db3 for Gaussian and blurred and db15 for salt & pepper noise.

🞣 The results for Symlets Wavelets are;
❖ The sym10 gives better results for speckle for Ultrasound and all PSNRs are equal for blurred noise.

- ❖ The sym4 gives better results for Gaussian for CT, sym5 for poisson and sym30 for salt & pepper and blurred noise.
- ❖ The sym4 gives better results for poisson for X-ray and sym30 for salt & pepper noise.
- ❖ The sym4 gives better results for Rician for MRI, sym25 for poisson and sym30 for Gaussian, salt & pepper and blurred noise.

2.3 Comparison one type of noise with different variance

When the differences in the noise value are small, the PSNRs are approximately equal or there is little change in the results.

- ▪ Speckle for Ultrasound.
- ▪ Gaussian for CT.
- ▪ Rician for MRI.

2.4 Comparison two type of noise

When the image is exposed to two types of noise, one is static and the other is variable;

- ▪ X-ray (poisson noise constant and salt & pepper variable).CT (Gaussian noise constant=0.02 and salt & pepper variable).
- ▪ Ultrasound (speckle noise constant=0.02 and salt & pepper variable).
- ▪ MRI (Rician noise constant=9 and salt & pepper variable).

The results from types of Wavelets are;

- ❖ For X-ray the highest PSNRs from db10, bior4.4, bior5.5, bior6.8, coif5, sym10 and sym15.
- ❖ For CT the highest PSNRs from db3, db10, bior4.4, bior6.8, coif5, sym10 and sym15.
- ❖ For Ultrasound the highest PSNRs from db10, bior4.4, bior6.8, coif5, sym10 and sym15.
- ❖ For MRI the PSNRs are approximately equal or there is little change in the results from all types of Wavelets.

III. RESULTS AND DISCUSSIONS

There are many filters used to purify the medical image, as we explained in Sec**I**. But we used Wavelet filter in this article and explained that there are different types of it Sec**II** and its results differ with the noised medical image depending on the type of image and the type of noise is exposed to as in **SecII** and figures below:
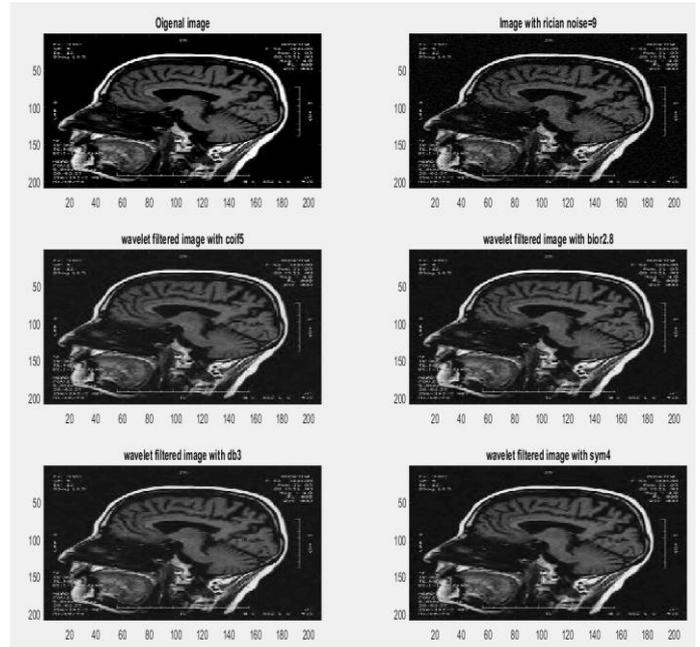

Figure 1: Comparison MRI image corrupted with Rician=9 noise and the results from filters
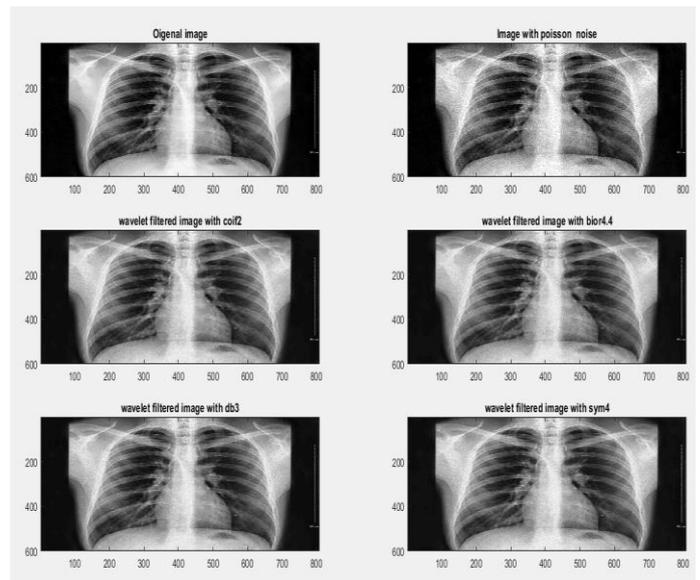

Figure 2: Comparison X-ray image corrupted with poisson noise and the results from filters
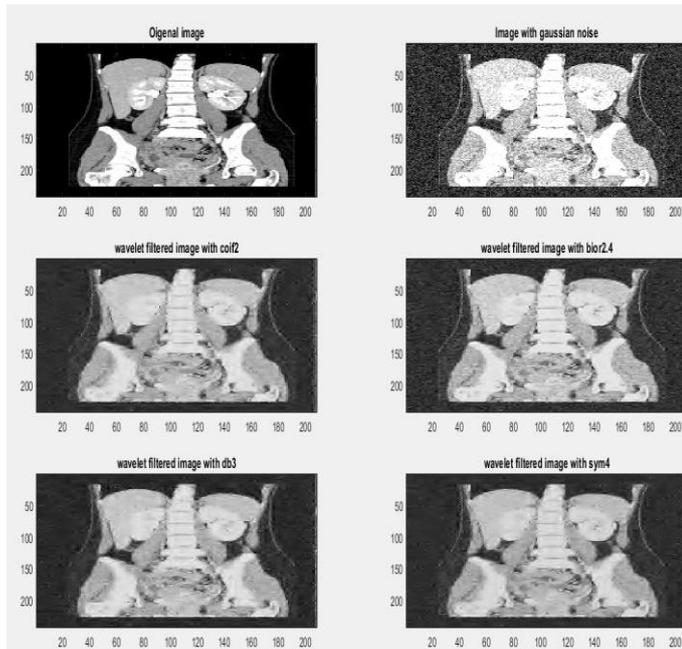
Figure 3: Comparison CT image corrupted with gaussian=0.2 noise and the results from filters
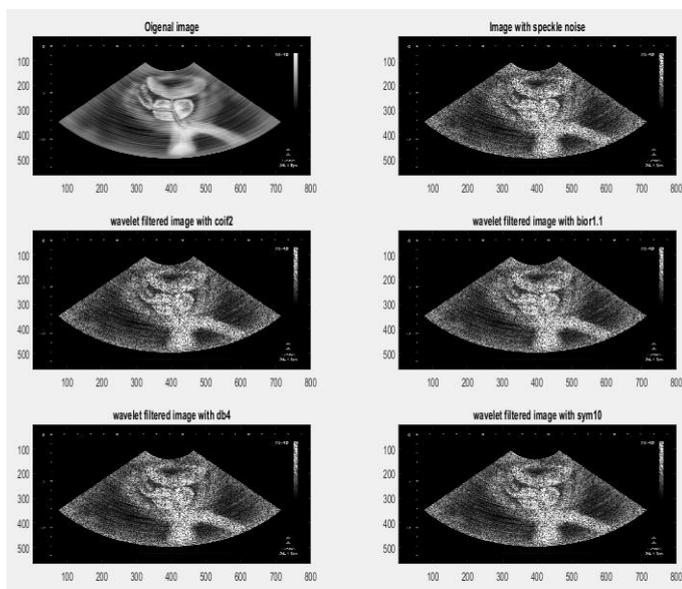

Figure 4: Comparison Ultrasound image corrupted with speckle=0.2 noise and the results from filters

IV. CONCLUSION

In medicine, doctors face the problem of recovering images if they are exposed to any kind of noise. It is required to obtain the image in the highest quality without losing the information obtained by the image. There are many methods used to remove this noise, and the method used here is the types of Wavelets and it turns out that each type differs in the value of PSNRs resulting from it with its use in the types of medical imaging, also with the type of noise exposed to the image, the value of the noise in the image and if it is of one type or more.

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