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Wavelet Based Denoising of MRI Images using Thresholding Techniques

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ABSTRACT: Image Denoising is an extremely significant part of different image process and computer image problems. The essential asset of good image denoising model is that it should finally remove noise as far as possible as preserve edges. One of most controlling and perception approaches in this area is image denoising by DWT. In this paper, comparison of various Wavelet at different families increased, and also using wavelet thresholding techniques and comparing the various parameters like PSNR, structural similarity index (SSIM), MSE (Mean square error) and Image quality of original and denoise image.

KEYWORDS: MRI, DWT, Wavelet Thresholding, Denoising

I. INTRODUCTION

MRI is a procedure used to provide very complete imagery of tissues as well as organs in human body. MRI is primarily used for assessing the pathological and physiological alteration of living tissue. MR images provide information that is similar to other imaging modalities such as X-ray and computed tomography in a method that is able to be characterized and separated among tissues using biochemical and physical properties. Also, not including moving patient it can create sectional images of equivalent resolution in projection which obtains images in multiple planes. Thus it adds to its flexibility and analytical utility and offers special compensation for radiation and surgical conduct planning.

The inherent elasticity of MRI allows its application in many clinical tasks other than imaging static structure. For the clinical diagnosis, the visual excellence of MR images plays an important role which can be seriously degraded by existing noise during the acquisition process. Despite significant improvements in a recent year, MRI is limited in spatial resolution and long imaging time. Noise in MRI follows a Rician Distribution and thus limits image assessment and this is problematic for further tasks like segmentation of important features, classification of images for computer, 3-dimensional image reconstruction and image registration. The existence of noise does not produce undesirable visual quality but it lowers the visibility of low contrast objects. Thus noise removal is an essential in medical imaging applications in which enhance and recover fine details that may be hidden within data.

In general, there are two ways to reduce the noise in the images. One is to obtain the data several times and average them but it increases acquisition time. One more way is to denoise the image by using post-processing methods. In the literatures, different approaches to denoise the image have been explained [19].

II. NOISES IN MRI

The ever-increasing number and selection of digital images generated and are becoming a major information source in daily life. These include natural images, magnetic resonance images, and geographical information systems and astronomy. When an image is created, transmitted and decoded, it is always distorted by different types of noise. Noise

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 7, July 2016

decrease has become required steps for complicated algorithms in computer vision and image processing. This challenging issue has existed for a long time, there is no completely satisfactory solution.

MRI, Cancer and Brain images often consists of the random noise this does not come from tissues but from other sources in the Electronics instrumentation during the acquisition. The noise of an image gives it a gray appearances and mainly the noise is evenly spread and more uniform. In this situation it is very difficult to diagnosis the particular disease. Therefore it is necessary to noise remove from the image. A signal or a image is unfortunately corrupted by various factors which effects as noise during transmission or acquisition. And the Filtering out these frequency components will cause perceptible loss of information of the desired signal when considered the frequency image of the original signal. It is clear that a method is required in order to save the important part of the signal having relatively high frequencies as the noise.

A. Gaussian Noise

Gaussian noise is a consistently distributed over the signal. This means every one pixel in the noisy image is sum of the correct pixel value and random Gaussian distributed noise significance. As the name indicates, this noise has a Gaussian distribution, which has bell shaped probability distribution function.

B. Salt & Pepper Noise

Salt and pepper noise is a impulse type of noise, which is also referred as intensity spikes which is caused generally due to the errors in data transmission. It has only two possible values, "a" and "b". The probability of each is less than 0.1. The corrupted pixels are set alternatively to the min or to the maximum value, which give the image as "salt and pepper" likes appearance. Unaffected pixels remains uncharenged The salt and pepper noise is generally caused due to malfunctioning of pixels element in the camera sensors, faulty memory locations, or timing errors in the digitization process.

C. Rician noise

It is multiplicative noise. Magnetic resonance magnitude (MRI) image data are usually modeled by Rician distribution. The Rician noise is used to refer to the error between the underlying image intensity and the observed data. Rician noise is not zero mean and mean depends on the local intensity in the image. The Rician probability density function is given by,

$$p(x) = \frac{x}{\sigma^2} \exp\left(-\frac{x^2 + A^2}{2\sigma^2}\right) I_0\left(\frac{x A}{\sigma^2}\right)$$

Where: σ is a standard deviation of the Gaussian distribution that underlies the Rician distribution noise

$$A^2 = A_1^2 + A_2^2$$

Where A_1 and A_2 are the mean value of two independent Gaussian components. Also, rician noise is signal dependent in high resolution, low signal to noise ratio system where it not only causes random fluctuations but also introduces as signal dependent bias to the data that reduces the mage contrast. It blurs images and it reduces the high frequency content of images such as edge, contours and also alters the intensity values of image pixels. Because of this tissues have different grey level distribution diagonally the image. Image processing algorithm like segmentation, classification or texture analysis use the grey level value of that image pixels which will not give satisfactory result.

III. ALGORITHM

The algorithms consists of the follow steps:

- Take the input MR image ('jpg', 'tif', 'png').
- Now Input image is converted in to double for the further process and add Rician noise, Gaussian and Salt and pepper noise in the original input image to obtain noisy MR image.
- Apply the 2D-Discrete Wavelet Transform on the noisy image to decompose the image up to 'J' levels into four sub-bands ('LL', 'LH', 'HL', and 'HH').
- Calculate Noise Variance and apply soft and hard thresholding technique to the noise coefficients as this method is continuous.
- compute the Inverse discrete wavelet transform to reconstruct the denoise image. Then the parameters, Peak Signal to Noise Ratio and Mean Square Error (MSE) and SSIM, Image Quality are calculated for all the

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 7, July 2016

wavelet families (db4, Symlet and coif) of standard images with their noisy and denoised counterparts, respectively. Hence, we get good quality amount of comparison between the noisy and denoised images keeping the set standard image intact.

IV. FLOW CHART

In medical images many wavelets like db4, db1, sym8, coif1, coif5, Meyer etc can be used for denoising of an medical image but we have used symlet4, coif4 and daubechies db4 at definite level of soft and hard threshold and then decomposed and reconstructed the denoised image. PSNR, MSE, SSIM values are calculated for comparing these wavelets.

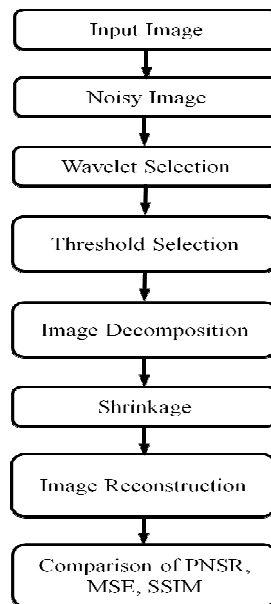


Fig:1 Flow chart

V. RESULT

We used MATLAB to implement de-noising algorithm. MATLAB has wavelet toolbox and functions which are very convenient to do the DWT. A usual way to the de-noise is to find a processed image such that it minimizes MSE and increases the value of the PSNR

For study purpose, we have taken 10 images, we have varied noise added to image, wavelet family and threshold techniques (hard & soft Thresholding)

After observing the results we can conclude the PSNR for Gaussian noise and pepper and salt noise is poor. Keeping other parameters (Wavelet families and Threshold techniques) constant, PSNR for Rician noise is better. So, it can conclude that a wavelet thresholding technique works well for rician noise as compared with Gaussian and pepper and salt noise.

Also, we have calculated PSNR values for input images and output images as shown in fig. From this it is observed that PSNR value of denoised image is much greater than input images.

Resultant images and graph for db4, coif4, symlet4 wavelet families using Hard and Soft thresholding to remove Rician noise, Gaussian noise and Salt & pepper noise are as follows:

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

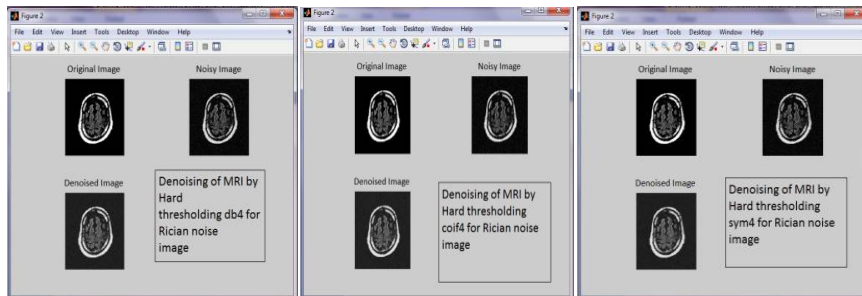


Fig: 2 Denoising of MRI by Hard Thresholding using db4, coif4, symlet4 for Rician noise Image

Fig 2 shows that denoising MRI by Hard Thresholding using db4,coif4, symlet4 for Rician noise Image. It is observed that PSNR is improved and MSE is less. So Image quality is improved for Rician noise hard thresholding using different wavelets.

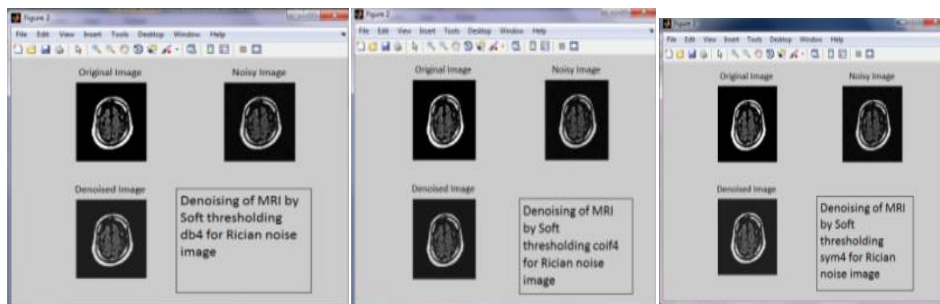


Fig: 3 Denoising of MRI by Soft Thresholding using db4,coif4,symlet4 for Rician noise Image

Above fig 3 shows that MR image by soft thresholding using db4, coif4, symlet4 wavelet for Rician noise. It is observed that PSNR is improving only 1dB. Noise is merge remove. So image quality is not better for soft thresholding using different wavelet.

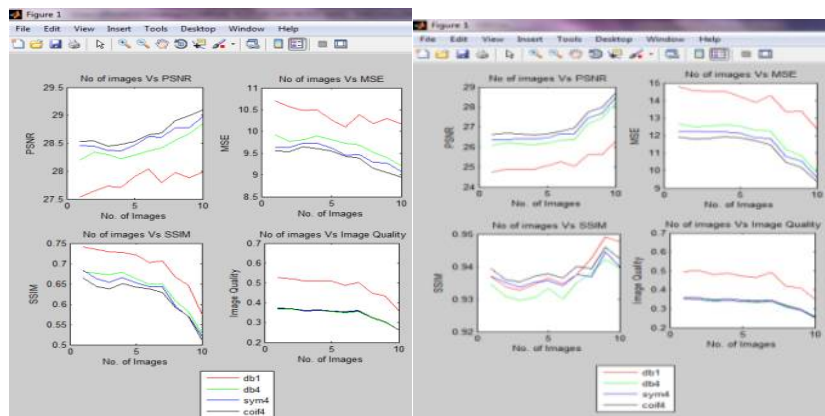


Fig: 4 Comparison for Rician noise Hard and Soft Thresholding using different Wavelet (db4, coif4, sym4) Graph

By comparing soft and hard thresholding ,it is observed that PSNR values for hard thresholding is better as compared to soft thresholding when it is used for Rician noise and also MSE is less in case of hard thresholding. So Image quality is better Rician noise using hard thresholding.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

Here also observed the graph fig 4. in Hard and Soft thresholding using different wavelet families. In this graph red color is taken the graph of db1 and green color is taken the graph of db4 and blue color is taken the graph of symlet4 and black color is taken the graph of coif4. It is seen that PSNR of coif4 wavelet is increase and MSE is inverse of PSNR. So Rician noise hard thresholding using coif4 wavelet has better performance as compared to other wavelet.

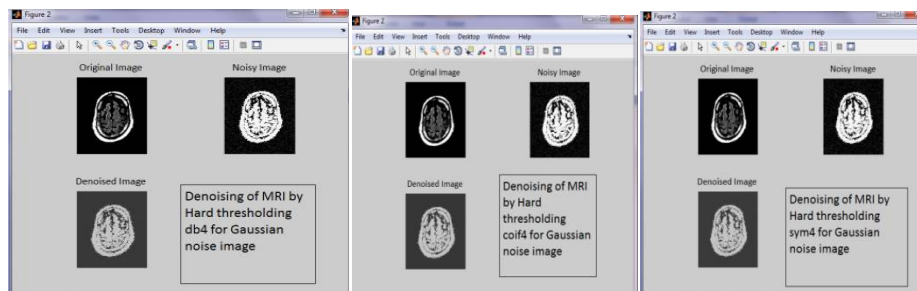


Fig: 5 Denoising of MRI by Hard Thresholding using db4, coif4, symlet4 for Gaussian noise Images

Fig 5 shows that denoising MRI by Hard Thresholding using db4, coif4, symlet4 for Gaussian noise Image. It is observed that PSNR is improved and MSE is less. So Image quality is improved for Rician noise hard thresholding using different wavelets.

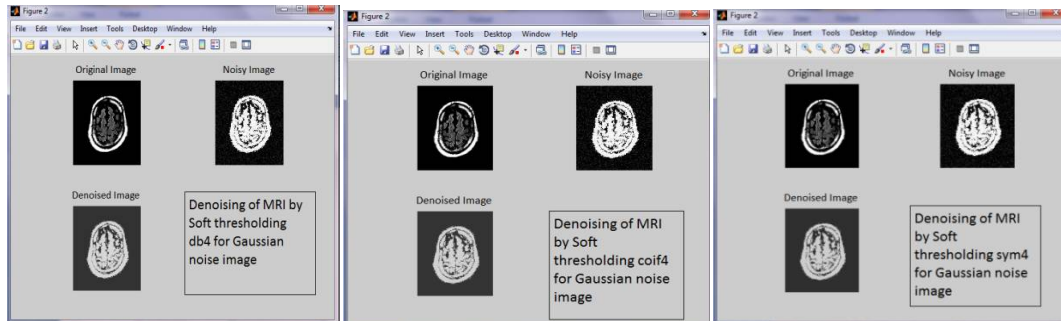


Fig: 6 Denoising of MRI by Soft Thresholding using db4, coif4, symlet4 for Gaussian noise Images

Above fig 6 shows that MR image by soft thresholding using db4, coif4, symlet4 wavelet for Gaussian noise. It is observe that PSNR is decrease. So image quality is not better for soft thresholding using different wavelet.

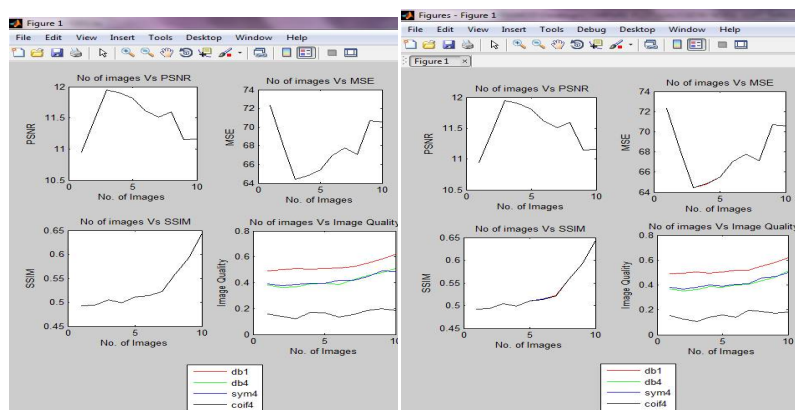


Fig: 7 Comparisons for Gaussian noise Hard and Soft Thresholding using different Wavelet (db4, coif4, sym4) Graph

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

By comparing soft and hard thresholding, it is observed that PSNR values for hard thresholding is better as compared to soft thresholding when it is used for Gaussian noise and also MSE is less in case of hard thresholding. So Image quality is better Gaussian noise using hard thresholding. Here also observed the graph fig 7. In Hard and Soft thresholding using different wavelet families. It is seen that PSNR of *coif4* wavelet is increase and MSE is inverse of PSNR. So Gaussian noise hard thresholding using *coif4* wavelet have better performance as compared to other wavelet.

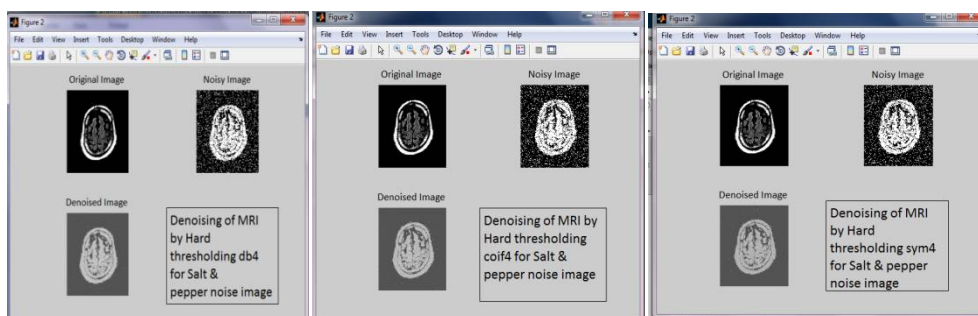


Fig: 8 Denoising of MRI by Hard Thresholding using *db4*, *coif4*, *symlet4* for Salt & pepper noise Images

Fig 8 shows that denoising MRI by Hard Thresholding using *db4*, *coif4*, *symlet4* for Salt & pepper noise Image. It is observed that I/p and O/p PSNR is same. So noise is not removing and Image quality is not better for Salt & pepper noise hard thresholding using different wavelets.

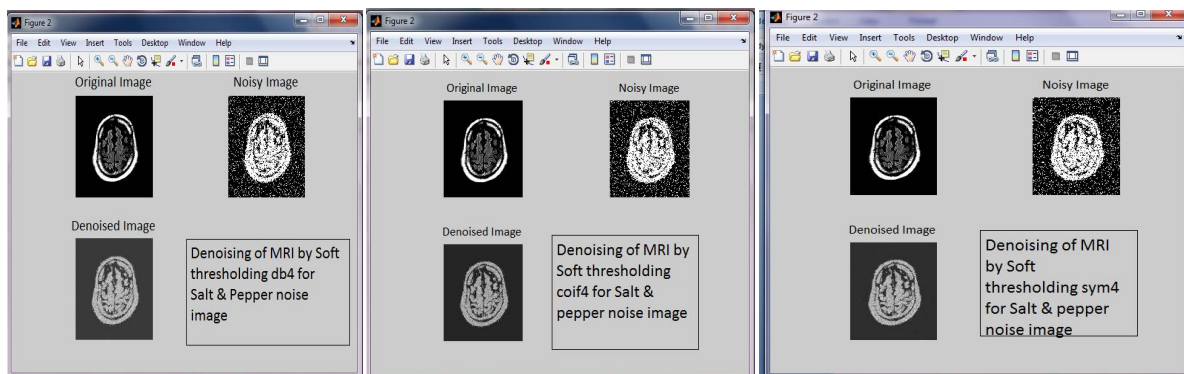


Fig: 9 Denoising of MRI by Soft Thresholding using *db4*, *coif4*, *symlet4* for Salt & pepper noise Images

Fig 9 shows that denoising MRI by Soft Thresholding using *db4*, *coif4*, *symlet4* for Salt & pepper noise Image. It is observed that I/p and O/p PSNR is same. So noise is not removing and Image quality is not better for Salt & pepper noise soft thresholding using different wavelets.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

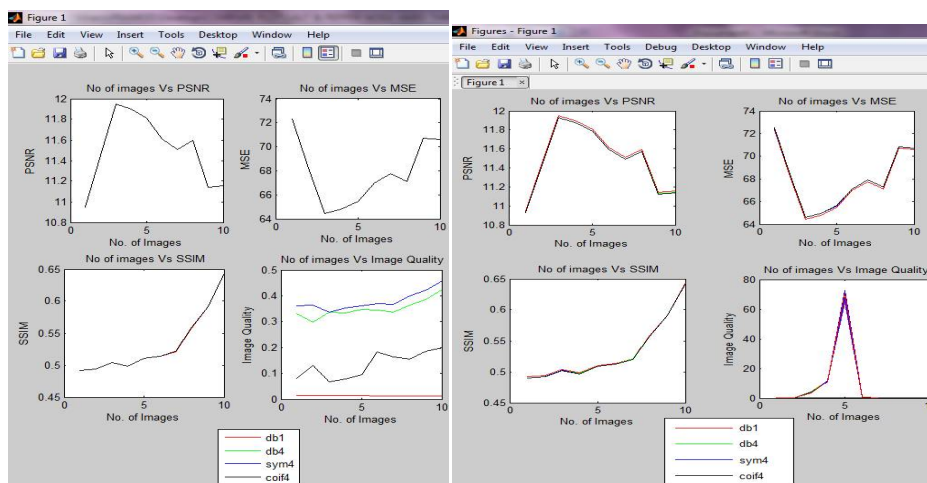


Fig: 10 Comparison for Salt & pepper noise Hard and Soft Thresholding using different Wavelet (db4, coif4, sym4) Graph

By comparing soft and hard thresholding, it is observed that PSNR values for Hard and Soft thresholding is decrease and same. When it is used for Gaussian noise and also MSE is less in case of hard thresholding. So Image quality is not good.

Here also observed the graph fig 10. in Hard and Soft thresholding using different wavelet families. In this graph red color is taken the graph of db1 and green color is taken the graph of db4 and blue color is taken the graph of symlet4 and black color is taken the graph of coif4. It is seen that PSNR of all wavelet families is decrease or almost same so graph are overlapping. So Salt & pepper noise hard and soft thresholding using all wavelet families have not better performance.

Table 1. Comparison of parameters for different wavelet families using Soft and hard thresholding

Wavelet	Thresholding	Noise	PSNR	MSE	SSIM	IMG QTY
Db4	Hard	Rician	28.25	9.85	0.67	0.36
			28.32	9.77	0.67	0.36
Db4	Soft	Rician	26.11	12.60	0.93	0.35
			26.16	12.53	0.93	0.34
Coif4	Hard	Rician	28.54	9.53	0.66	0.37
			28.60	9.46	0.65	0.37
Coif4	Soft	Rician	26.61	11.91	0.93	0.35
			26.62	11.89	0.93	0.35
Sym4	Hard	Rician	28.42	9.66	0.67	0.37
			28.56	9.62	0.67	0.36
Sym4	Soft	Rician	26.39	12.21	0.93	0.35
			26.39	12.22	0.93	0.35
Db4	Hard	Gaussian	29.09	8.94	0.49	0.38
			29.23	8.81	0.49	0.37
Db4	Soft	Gaussian	25.20	14.00	0.49	0.37
			25.88	13.88	0.49	0.36

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

Coif4	Hard	Gaussian	29.95	8.48	0.49	0.15
			29.60	8.43	0.49	0.15
Coif4	Soft	Gaussian	25.69	13.54	0.49	0.13
			25.69	13.54	0.49	0.14
Sym4	Hard	Gaussian	29.30	8.73	0.49	0.39
			29.40	8.63	0.49	0.38
Sym4	Soft	Gaussian	25.49	13.54	0.49	0.39
			25.49	13.54	0.49	0.36
Db4	Hard	Salt & pepper	26.41	12.17	0.49	0.33
			26.72	11.74	0.49	0.31
Db4	Soft	Salt & pepper	26.54	12.00	0.49	0.30
			26.62	11.88	0.49	0.28
Coif4	Hard	Salt & pepper	26.43	72.32	0.49	0.09
			26.57	69.21	0.49	0.11
Coif4	Soft	Salt & pepper	26.88	11.53	0.49	0.07
			26.90	11.52	0.49	0.09
Sym4	Hard	Salt & pepper	26.50	12.06	0.49	0.35
			26.58	11.94	0.49	0.30
Sym4	Soft	Salt & pepper	26.95	11.44	0.49	0.36
			26.91	11.95	0.49	0.33

Above table 1 shows that Comparison of parameters for different wavelet families using soft and hard thresholding it is observe that PSNR values for hard thresholding is better as compare to soft thresholding using Rician noise and Gaussian noise.

VI. CONCLUSION

Wavelet method or algorithm for image de-noising images are the most effective because of their ability to capture the energy of a signal in small energy transform values. Wavelet thresholding has proven to be efficient edge-preserving denoising method for gray scale images specially for removal the Rician noise. Wavelet transform provides localization in spatial and spectral domain. The discrete wavelet transform, on other hand, provides enough in sequence both for the analysis and the combination of the real signal, with a considerable reduction in the calculation time. From that experimental result and comparison of parameters, it shows that that this technique works very well when used for Rician noise and Gaussian noise, having the highest PSNR, less MSE. While comparing with wavelet families, coiflet4 has having better results as compared the other.

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