

Analysis of Denoising Techniques with Application in Medical Images

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Abstract - Medical images like MRI, CAT scan, and ultrasound play role of back bone in diagnostics. Images generated from various medical diagnostic machines are transmitted through channels before used by clinical experts. Transmission through noise channel sometimes degrades and corrupts the image making it inappropriate for accurate diagnose. The aim of this article is to study and analyse the effect of noise on medical images. Different types of noises were intentionally added such as Gaussian, Salt and Pepper, Speckle and Poisson and corrupted the medical images with varying values of mean and variance. Different filtering algorithm: Anisotropic

Diffusion, Wavelet Thresholding, NL-Means and Wavelet are applied to de-noise images. Simulation results include comparison of effect of different noise and consequently de-noising. The effectiveness of discussed algorithms were compared on the basis of: Signal to Noise Ratio (SNR), Peak to Signal noise ratio (PSNR), Mean square Error (MSE).

I. INTRODUCTION

The handling of digital images has become a subject of widespread interest in different areas especially in medical field. For achieving an accurate and efficient diagnosis, medical staff requires substantial quality digital images. However, in their acquisition or transmission procedures, images may be corrupted by a disruptive noise, which could mask the subtle and meaningful features. Therefore obtained images from clinical examinations should be treated to assist doctors in results interpretation accurately. In order for a correct diagnosis, these medical images are required to be noise free. Here we highlights the various filtering algorithms that are applied on the corrupted medical images to make them noise free. We have intentionally added different types of noises such as Gaussian, Salt and Pepper, Speckle and Poisson. Medical images are corrupted with varying values of mean and variance and then denoising is applied. Basic filters like Averaging, Median, Weiner and Adaptive filters are applied for preprocessing. We have implemented various filtering algorithms Anisotropic Diffusion, Wavelet Thresholding, Total Variation, NL-Means, Decision Based algorithm and Wavelet on various medical images such as Magnetic Resonance, X-rays, and Ultrasound. The effectiveness of discussed algorithms is compared on the basis of Peak to Signal noise ratio (PSNR), Mean square Error (MSE), Signal noise ratio SNR.

II. NOISE MODEL

Medical field hugely depends on computer graphic in terms of usage of MRI, CAT, Xray AND ULTERSOUND for the purpose of diagnostics. Images like MRI contains high degree of noise and randomness associated with it. Main source of noise is during acquisition and transmission while taking patients various scans. Noise induced during transmission could be of different type. Noise model depicts the spatial and frequency characteristics of noise. Following are the basic noise models. Where $f(x,y)$ is original image acquired from various diagnostic machines. Noise induced is represented by $n(x,y)$. Effected image is given by following degradation model.

$$\widehat{f(x,y)} = f(x,y) + n(x,y)$$

Original Image	<ul style="list-style-type: none"> ➤ MRI scan ➤ CAT scan ➤ X- ray ➤ Ultrasound 	Noise Induces	<ul style="list-style-type: none"> ➤ Gaussian noise ➤ Possion ➤ Salt
De-noising	<ul style="list-style-type: none"> ➤ Non local means ➤ Wavelet thresholding ➤ Anisotropic diffusion 	Comparison	<p>Parameter of Comparison</p> <ul style="list-style-type: none"> ➤ PSNR ➤ SNR ➤ MSE

Figure : Degradation Model

WAVELET THRESHOLDING methods are used for noise removal. Wavelet coefficients are processed in order to remove noise[Rami Cohen].

The thresholded wavelet coefficients are obtained using either hard or soft thresholding rule given respectively by:

The de-noising technique is carried out in the following manner:

Step1. Load 8 bit image of size 512 * 512.

Step2.Analyzing an image

Step3.Performing decompositions and reconstructions (command line only)

Step4. De-noising an image

$$F_s(x) = \begin{cases} x - \lambda & \text{if } x \geq \lambda \\ 0 & \text{if } |x| < \lambda \\ x + \lambda & \text{if } x \leq -\lambda \end{cases}$$
 NL MEANSparametric filter named Non-local mean is used for MRI image denoising[2]. Unlike other local smoothing filters, non-local means filter averages all observed pixels to recover a single pixel. The weight of each pixel depends on the distance between its intensity grey level vector and that of the target pixel.

The wavelet de-noising procedure involves three steps. The basic version of the procedure follows these steps:

Step1. Decomposition of image:Choose a wavelet, choose a level N. Compute the wavelet decomposition of the signal s at level N.

Step2.Threshold detail coefficients: For each level from 1 to N, select a threshold and apply soft thresholding to the detail coefficients.

Step3.Reconstruct of image:Compute wavelet reconstruction using the original approximation coefficients of level N and the modified detail coefficients of levels from 1 to N.

III. RESULTS

After comparing the results of all the above mentioned denoising techniques, we can conclude the following:Wavelet thresholding removes speckle noise most efficiently and doesn't remove salt &pepper noise as shown in Table 1 and Table 2. NON LOCAL MEANS: Gaussian noise is most effectively removed by it.

NOISE	READING	NON LOCAL MEANS	ANISOTROP IC	DIFFUSION	WAVELET THRESHOLDING
	GAUSSI	PSNR	73.24	22.84	26.23
	SNR	13.04	4.88	14.45	
	MSE	0.003	342.00	155.88	
SPECK	PSNR	72.85	23.35	27.54	
	SNR	12.30	4.86	15.10	
	MSE	0.003	302.47	115.28	
SALT	PSNR	77.53	23.23	27.49	
	SNR	16.96	4.83	15.07	
	MSE	0.0012	310.93	116.57	
POISS	PSNR	83.27	23.85	32.04	
	SNR	22.69	4.73	19.59	
	MSE	0.0003	269.65	40.97	

Table 2.

NOISE	READING	ULTRASOUND	MRI	CT-SCAN	X-RAY
	GAUSSIAN	PSNR	28.59	23.87	30.89
	SNR	14.44	11.43	19.72	17.98
	MSE	90.63	268.36	53.28	105.25

IV. CONCLUSION

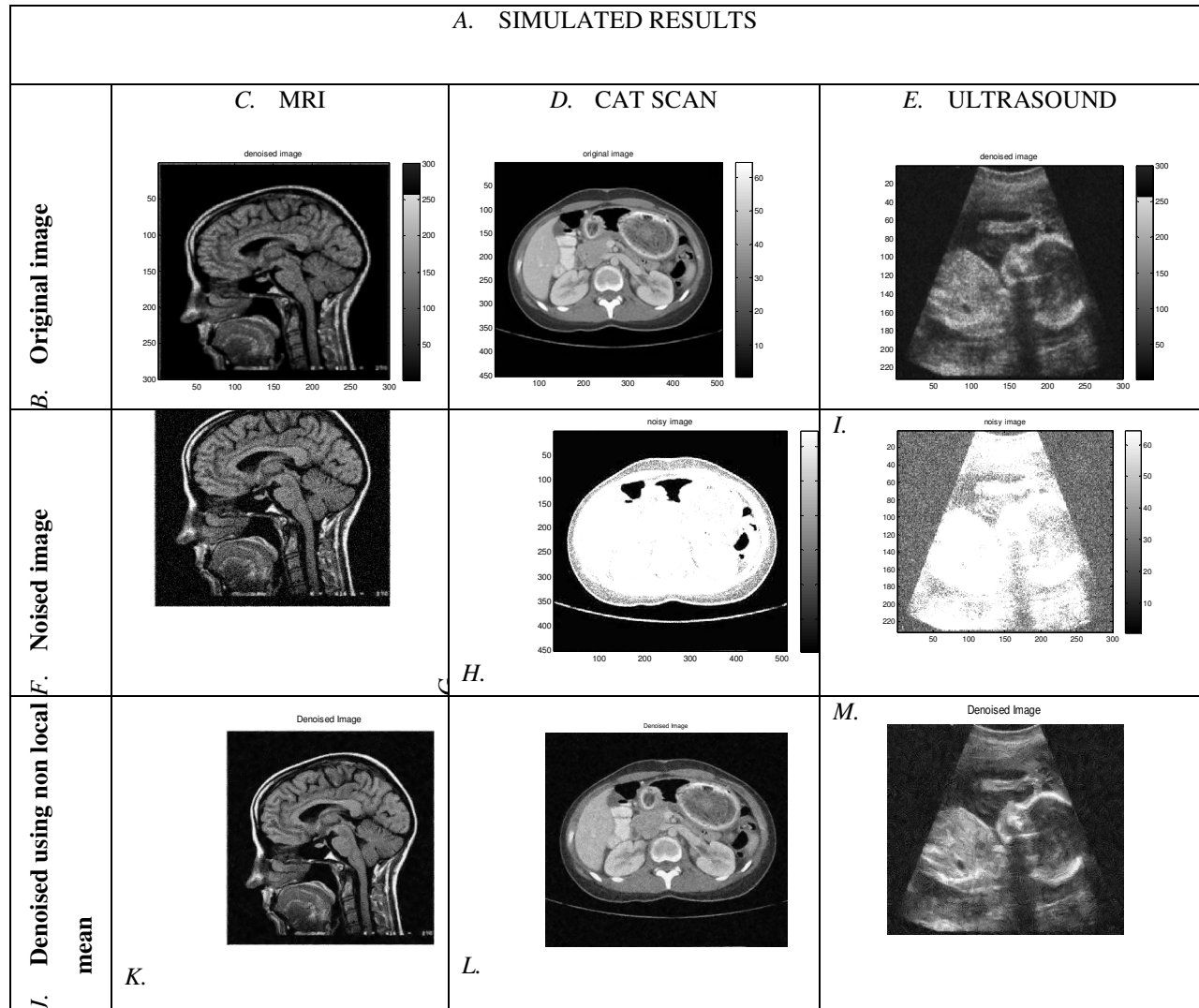
Three denoising techniques analyzed conclude to following main results. NL mean removes all the four noises effectively. Wavelet thresholding removes all the four noises to certain extent. Wavelet de noising it only removes Gaussian noise but does not give acceptable result for other noises.

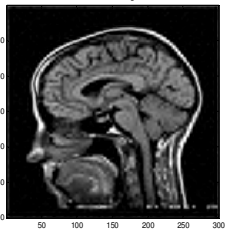
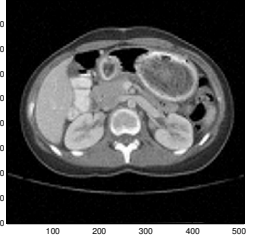

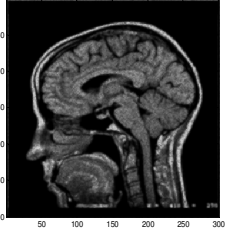
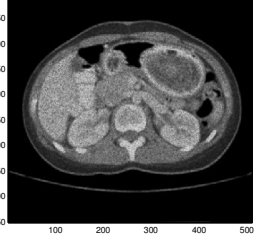
V. FUTURE SCOPE

Future research in the filtering of medical images will strive towards improving the accuracy, precision and computational speed of filtering methods, as well as reducing the amount of manual interaction.

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<p>N. Denoised using wavelet</p>	<p><i>O.</i></p> 	<p><i>P.</i></p> 	<p><i>Q.</i></p> 
	<p>R. Denoised using wavelet thresholding</p>	<p><i>S.</i></p> 	<p><i>T.</i></p> 

V.