Wavelet-Based Weighted Median Filter for Image Denoising of MRI Brain Images

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ABSTRACT

Preliminary diagnosing of MRI images from the hospital cannot be relied on because of the chances of occurrence of artifacts resulting in degraded quality of image, while others may be confused with pathology. Obtained MRI image usually contains limited artifacts. It becomes complex one for doctors in analyzing them. By increasing the contrast of an image, it will be easy to analyze. In order to find the tumor part efficiently MRI brain image should be enhanced properly. The image enhancement methods mainly improve the visual appearance of MRI images. The goal of denoising is to remove the noise, which may corrupt an image during its acquisition or transmission, while retaining its quality. In this paper effectiveness of seven denoising algorithms viz. median filter, wiener filter, wavelet filter, wavelet based wiener, NLM, wavelet based NLM, proposed wavelet based weighted median filter(WMF) using MRI images in the presence of additive white Gaussian noise is compared. The experimental results are analyzed in terms of various image quality metrics.

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1. INTRODUCTION

The image acquired by the acquisition device is susceptible by the environment. The restoration of images tries to minimize the effects of these degradations by means of a filter [1]. Therefore, a fundamental problem in the image processing is the improvement of their quality through the reduction of the noise [2]. A great variety of techniques dedicated to carry out this task exist. Each of them depends on the types of the noise in images. Noise not only lowers image quality but also can cause feature extraction, analysis and recognition algorithms to be unreliable The MRI images are normally affected by a type of noise called gaussian Noise. The presence of noise hampers diagnosis. The diagnostic and visual quality of the MR images are affected by the noise added while acquisition. Noise removal is essential in medical imaging applications in order to enhance and recover anatomical details that may be hidden in the data. In recent years, wavelet transform [3] shows a clear advantage in the field of image denoising domains, and has many research results. The important property of a good image-denoising model is that it should completely remove noise as far as possible as well as preserve edges. The paper is organized as follows: Section II describes methodology of the proposed system. Section III describes denoising performance measures and also Experimental results are provided, followed by summary, conclusion in section IV and V. This paper compares recent existing denoising schemes with proposed wavelet based weighted median filter.

2. PROPOSED WAVELET BASED WEIGHTED MEDIAN FILTER

This proposed approach; First MR brain image is subjected to AWGN noise and is decomposed by Haar wavelet transform produces *l* scales, and then 3*l*+1 sub images. High frequency sub-image contains edge feature of an image, detail information and also noises mainly concentrated on high frequency components. Second to preserve the edges “sobel masks [9]”are applied to horizontal, vertical and diagonal sub images; then each sub images produces binary edge patterns. Based on the binary edge map, filtering is performed. That is, if the position (*m*,*n*) in the sub-image belongs to an edge, denoising process is not performed. On the other hand, if the position (*m*,*n*) does not belong to an edge, denoising process has been performed using weighted median filter with 5x5 mask on each sub image. Third combine 3 binary edge maps which have produced 4th binary edge map using this, filtering has performed on low frequency sub image by weighted median filter. Finally through inverse Haar transform, the enhanced image is obtained. The alleged method removes noises and preserves edges effectively without blurring the details. The experimental results disclose that the proposed method is effective in filtering the noises. Table1 shows the performance of listed filters [4]-[7], [10], [11]. For Concluding, the best filter [12] of wavelet based weighted median filter is identified and used for MR brain image enhancement. It is used for diminishing noise from MRI brain image and also preserves edges even at high noise level with high contrast [13]. The performance analysis of the filters is compared in terms of peak-signal-to-noise ratio, and signal-to-noise ratio, MSE quantitatively; the proposed method has produced high PSNR and low MSE comparable to other methods. Figure 1, shows different denoising mechanism of MR brain image Figure 2. Shows denoising outputs of MRI brain images corrupted by AWGN noise of 10% and 20% probability densities. Figure 3 illustrates the graphical representation of MSE, PSNR, SNR of 10% and 20% noise density.

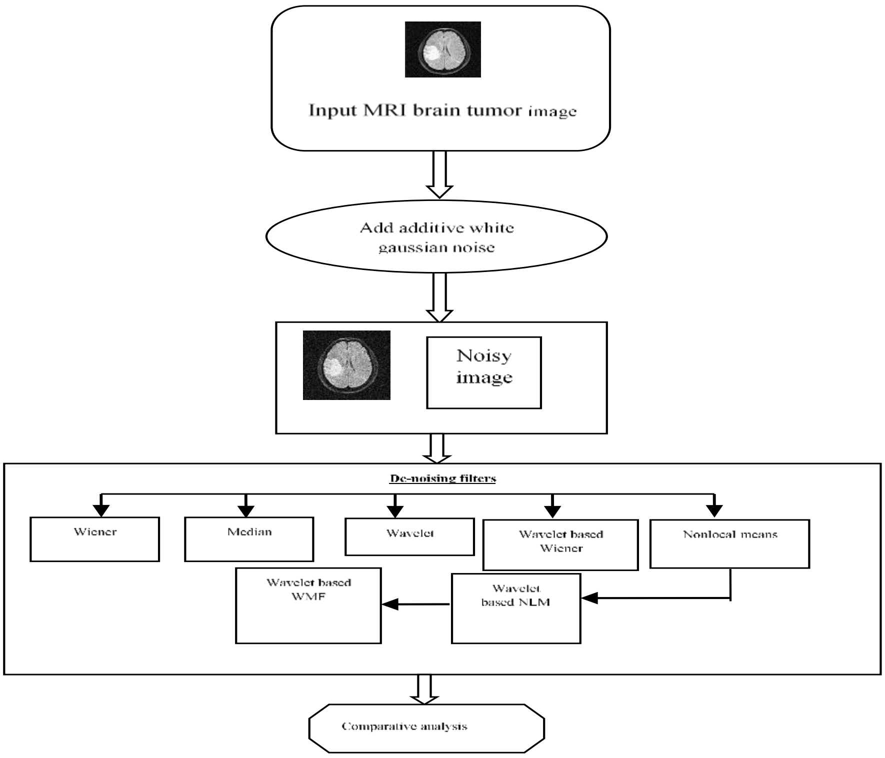

Figure 1. Block diagram of different denoising mechanism of MR brain image

Algorithm for proposed weighted median wavelet filter

Input: Noisy image N of size(m*n)
Output: DN -> Denoised image
[H V D A] = wavelt_decompose(N) using Harr, Wavelet components
for each H V D A as I
Find sliding windo for I hich windo of size 3*3 -> K

```
        for each window K
C = center pixel of K
if C = max(K) and c = min(K)
        noise = 1;
else
        noise = 0;
endif
end for
Find Noise Density, Noise Density = (number of noise pixel / number of pixel in I)
```

Noise Density	Suggested W_{D1} * W_{D1}
0% < p ≤ 15%	3*3
15% < p ≤ 30%	5*5
30% < p ≤ 45%	7*7
45% < p ≤ 60%	9*9
60% < p ≤ 70%	11*11

```
b=edge(I) by sobel
for x=1 to Row size of I
for y = 1 to column size of I
if b(x,y) == 1
        d(x,y) = I(x,y)
else
Find sliding which window of size WD1 * WD1 * -> K
for each window K
C = center pixel of K
if C = max(K) and C = min(K)
        d(x,y) = weighter median filter is performed on c(x,y)
else
        d(x,y) = I(x,y)
endif
end for
endif
end for
end for
update H V D A by d
end for
Dn = wavelet_compose(H,V,D,A);
```

3. DENOISING PERFORMANCE MEASURES

A. PSNR

The PSNR computes the peak signal-to-noise ratio, between two images in the unit of decibels [14]. This ratio is often used as a quality measurement between the original and a compressed image. The higher the PSNR, the better the quality of the compressed [8] or reconstructed image.

$$PSNR_{dB} = 10\log_{10}\left(\frac{MAX^2}{MSE}\right) \tag{1}$$

B. MSE

The *mean square error (*MSE) quantifies the strength of error signal and is calculated according to the formula

$$MSE = \frac{1}{\boldsymbol{mn}}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \tag{2}$$

Where $\boldsymbol{mn}$ is the image dimension, $I(i,j)$ and $K(i,j)$ represents the intensities of pixels (i, j) in the original image and denoised image, respectively.

C. SNR

The *signal to noise ratio (*SNR) determines how grainy the image appears, the more grainy, the less the SNR. The SNR is measured frequently by calculating the difference in signal intensity between the area of interest and the background.

$$SNR = 10log_{10}\frac{\sum x_i \in \Omega^2 (v(xi)^2 - \hat{v}(xi)^2)}{\sum x_i \in \Omega^2 (v(xi)^2 - \hat{v}(xi)^2)} \quad (3)$$

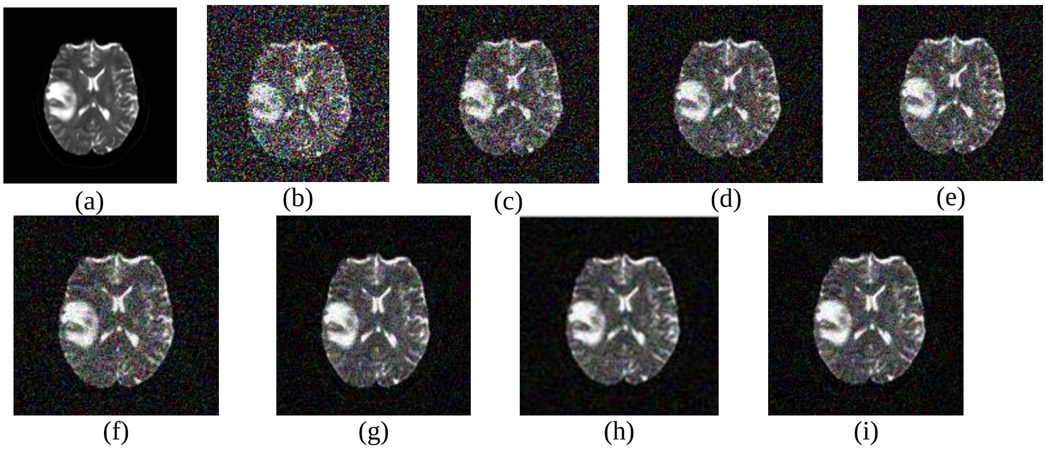

Figure 2. Denoising outputs of MRI brain images corrupted by AWGN noise of 10% probability density (a) Input image (b) Noisy image-AWGN (c) After wiener filter (d) After median (e) After wavelet (f) After wavelet-median (g) NLM (h) wavelet-NLM (i) Proposed wavelet based WMF

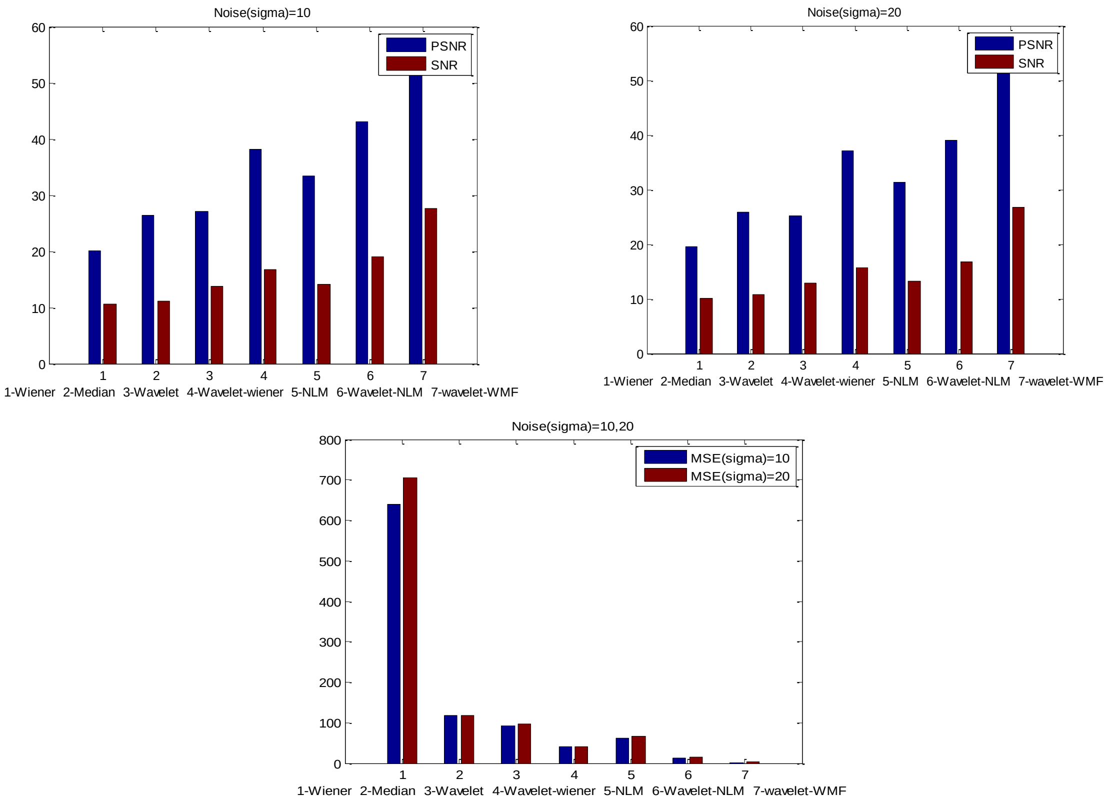

Figure 3. PSNR, SNR and MSE comparison of various denoising schemes for Noise (σ)=10, 20

Table 1. Qualitative analysis-different denoising schemes of mr (magnetic resonance) brain image corrupted by additive white gaussian noise

Denoising schemes	Noise(σ)=10			Noise(σ)=20		
	PSNR	SNR	MSE	PSNR	SNR	MSE
Wiener Filter[4]	20.07	10.60	639.93	19.64	10.17	706.13
Median filter[5]	26.45	11.21	117.13	25.99	10.87	119.12
Wavelet-soft thresholding[6]	27.14	13.81	92.34	25.16	12.61	97.71
Wavelet based wiener[7]	38.13	16.75	41.15	37.11	15.67	42.02
NLM[10]	33.42	14.11	62.17	31.23	13.33	67.66
Wavelet Based NLM Filter[11]	43.12	18.98	12.34	39.11	16.71	14.45
Proposed wavelet based WMF	56.89	27.71	1.223	51.21	26.11	3.112

4. SUMMARY

The experiments were conducted on T2 weighted MRI datasets, which are corrupted with additive white Gaussian noise, the images are acquired using Siemens Magnetom Avanto 1.5TScanner. T2 weighted MR brain image with TR = 4000ms, TE = 114 ms, 5mm thick and 590×612 resolution. Well-known objective evaluations such as MSE, SNR and PSNR have been used for measuring the image quality. The comparisons of seven denoising schemes are tabulated in Table1. It is observed from the Table 1, for T2 weighted MR brain images wavelet based weighted median filter technique gives better result as compared to other denoising schemes. Higher the value of PSNR and higher the value of SNR, lower the value of MSE shows that the proposed wavelet based weighted median filter perform superior than the other denoising methods. From the enhanced results, quantitatively the method produces good PSNR outputs.

5. CONCLUSION

In this article, the performance comparison of various filtering methods for removing additive white Gaussian noise from MR images have been discussed. In this work T2 weighted MRI brain images were used. The wavelet based weighted median filter method tends to produce good denoised image not only in terms of visual perception but also in terms of the quality metrics such as PSNR, SNR and MSE. Hence the new proposed algorithm is found to be more efficient than the other methods in MR brain image denoising particularly for the removal of Gaussian noise. Thus the obtained results in qualitative and quantitative analysis show that this proposed algorithm outperforms the other methods both visually and in terms of PSNR. SNR, MSE.

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