Performance Measure in Medical Image Denoising capabilities of Wavelet Transform and Diffusion Filter

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ABSTRACT

The paper demonstrates the denoising of Medical image using multi-resolution wavelet transform and diffusion filter. Medical Image denoising is a common procedure in digital image processing aiming at the removal of noise, which may corrupt an image during its acquisition or transmission, while retaining its quality. There are several approaches were introduced for performing denoising with Wavelet and diffusion were found to the best for total noise elimination. This paper demonstrates comparison of wavelet and diffusion filters through objective evaluations approach for their denoising capabilities and based on signal-to-noise ratio (SNR), mean squared error (MSE), peak signal-to-noise ratio (PSNR), and Structural Similarity Index Metric (SSIM). It is found that diffusion filter overcome wavelet transform filter in remaining the structural of the image unaffected and in improving the quality of the images.

Keywords: Medical Image, Performance capabilities, signal-to-noise ratio (SNR), mean squared error (MSE), Peak signal-to-noise ratio (PSNR), Structural Similarity Index Metric (SSIM)

Introduction

Medical mage denoising is a procedure in digital image processing trying to eliminate noise, which might make the image shady while it is being transferred or taken, conserving its quality at the same time. Noise harms the visual quality of the medical

image and also decreases the appearance of objects which have a low contrast [1-4, 6]. People who have experience in this field are aware of the fact that making an image noise free along with conservation of its quality is a very difficult task to achieve most importantly when the minor details or hidden structures are to be made prominent [5, 7-9]. While making the design of any new filter the two contrasting goals of noise reduction and conservation of details are very difficult to achieve. For various applications that are used for image processing, assessment of image quality is important. The examination of quality of the image is almost similar to the examination of similarity of the image in which the basis of quality is the differences (or similarities) between the actual image and the image which has noise in it. Using the examination of image quality there are two methods that can help us assess quality of the image. While assessing quality of the image subjectively, human eye is considered to be the best instrument. It is based on the perception of an individual i.e. the way he sees the object. This assessment is most of the ties slow and costly and is very complicated to be repeated or checked for verification. Hence, in recent years' objective methods of assessment have gained popularity [10]. A mathematical model objective quality assessment produces results that are almost similar to the results obtained through subjective measures for the measurement of image quality [11-15]. The basic objective to use this method is to get measurement in terms of quantities which can then asses the observed quality of the image [16]. It has many functions such as, controlling the quality of the image so that it can be useful for quality control systems, to create standards for image processing systems and to adjust algorithms and limitations.

Medical image carried very useful information that and it is used for diagnosis purpose. In designing any new filter, two most contrasting problems are reducing the noise along with conservation of image quality. Furthermore, smoothing few areas

while not affecting other areas is considering another challenge. Some filters have been design for removing noise; yet there is no enough evident that these algorithms are efficient in removing the noise with less degrade to the original image, as a result performance evaluation is very necessary to evaluate the filter in removing noise.

Methods

After noise were introduced into online collected data, the measurement of the images was perfumed and it an essential step in various of image processing applications. Similarity assessment and image quality assessment are same with calculate the difference between the original image and the denoised image. In subjective image quality assessment IQA, the quality of an image is viewed by naked eyes as eventually it has to be seen by human eyes. Subjective image quality assessment related with how an image is recognized by the observer and what feedback he gives about a selected image. Subjective assessment is usually tiresome, slow, costly, and hard to be duplicated and confirmed. Hence, objective methods are able to get more attention. Here, determination of the finest spatial filter that implement to eliminate a special type of noise in the medical images is the most crucial step. Objectively, using matlab program four most significant similarity measures are employed to compare the image that restored after the process of denoising algorithm with the actual image. It starts with the measure of structural similarity index metric and the next step is the measure of SNR whiles the third step and fourth step are the PSNR and MSR. Furthermore, offered techniques on different benchmark images with various power spectrum are applied to verify and view its results.

The (SNR) is well known as signal processing for the approximation of noise. Here, it describes the extent to which the denoised image/signal has SNR compare it to

the original image/signal. This shows greater the SNR the best is the quality of denoised image/signal and the better is the filtering algorithm. The signal-to-noise ratio is given as:

$$(\mathrm{SNR})_{\mathrm{db}} = \frac{\mathrm{var}(\mathrm{avg}(\mathrm{I}_{\mathrm{denoised}}))}{\mathrm{var}(\mathrm{avg}(\mathrm{I}_{\mathrm{original}}))} \quad (1)$$

The measurements of image quality are done due to a square window that has the ability to move pixel-by-pixel through all the pixel in the original and denoised image correspondingly. For reaching at the required single value overall quality assessment of the complete image, the global image quality measurement is carried out by evaluating the root mean square of the image quality measurement.

This metric is applied as:

$$MSE = \frac{1}{NM}\sum_{i=1}^{N}\sum_{j=1}^{M}\left(I_{original}(i,j) - I_{denoised}(i,j)\right)^2 \quad (2)$$

$I_{original}$ is the original image before the denosing process and $I_{denoised}$ is the image after applying wavelet and diffusion filtering algorithms, the smaller the MSE, better denoising algorithm results into better image quality. The PSNR has described in decibel units (dB), it has the capability to measure the ratio of the peak signal and the dissimilarity lies among both images. A raise of 20 dB results into a ten-fold decrease in the RMS difference between two images [1]. There are various versions of signal-to-noise ratios whereas PSNR is usually used for image processing, possibly the reason can be better-sounding numbers given to it than by other measures. The PSNR can be evaluated as:

$$PSNR = 20log_{10}\frac{255}{RMSE} \quad (3)$$

The RMSE given is estimated among the actual image and the denoised image.

Results and discussion

The improvement in images after enhancement is difficult to be measure by our naked eye. A processed image is said to be enhanced over the original image if it allows the observer to better perceive the desirable information in the image after using proper algorithm. In the images the improved perception is difficult to quantify and measure. There is no universal measure, which can specify both the objective and subjective validity of the enhancement method or algorithm. In practice many definitions of the contrast measure are used to quantify the images. This study used signal-to-noise ratio, mean squared error, peak-signal-to noise ratio and structural similarity index metrics to evaluate the performance of the proposed algorithms.

The performance evaluation of the three proposed algorithms is as shown in the following tables. Wavelet transform overcomes diffusion filter in signal-to-noise ratio, mean squared error and peak signal-to-noise ratio while diffusion overcome wavelet transform in structural similarity index metrics. SSIM, is the best measure for image quality and in this study, diffusion performed better than wavelet transform. The set of pixel value of SNR, RMSE, PSNR and SSIM calculated for diffusion and wavelet transform filters for original image 1 are as given in table 1.

Table 1- *Performance Measure of Image 1*

Metrics Filters	$SNR_{(dB)}$	RMSE	$PSNR_{(dB)}$	SSIM
Diffusion	11.99	0.05	74.67	53
Wavelet	13.93	0.04	76.64	52

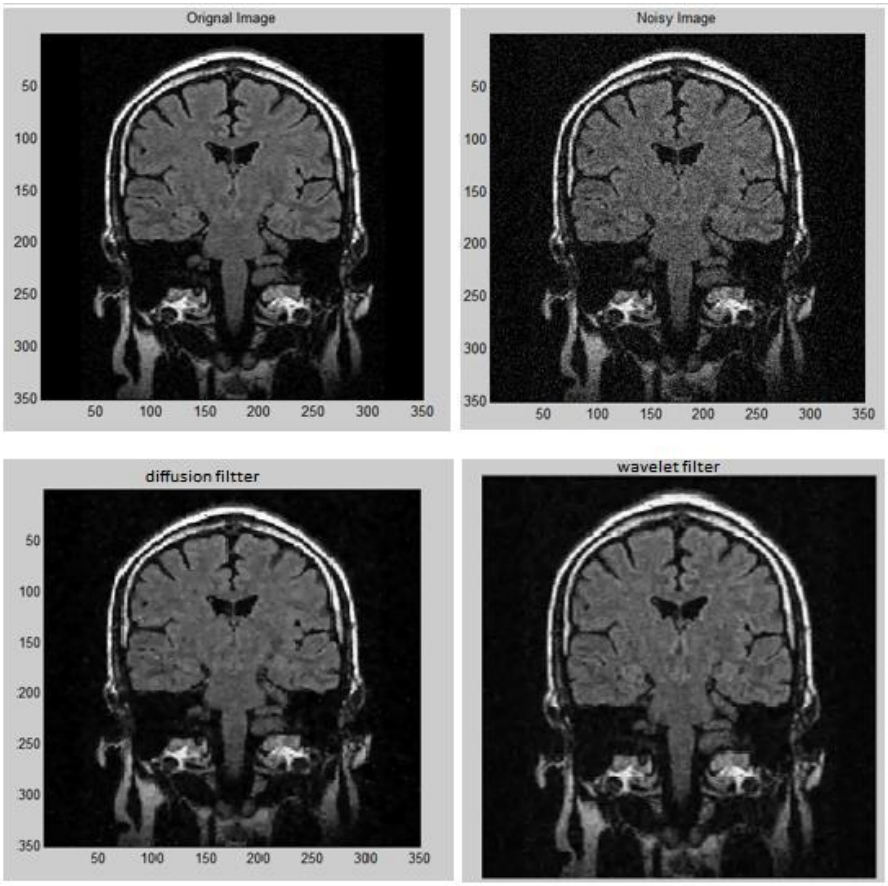

Figure 1: Sample Image 1

Figure 2 shows the performance analysis of the proposed algorithms in term of their signal-to-noise ratio, mean squared error, peak signal-to-noise ratio and the structural similarity index metrics. From the table (2) it can be seen that, wavelet transform overcome diffusion filter in signal-to-noise ratio, and peak signal-to-noise ratio. However, the performance of diffusion filter is higher and better than wavelet in term of SSIM metrics and the performance of mix filter is higher and better than diffusion in term of SSIM metrics.

Table 2- *Performance Measure of Image 2*

Metrics Filters	$SNR_{(dB)}$	RMSE	$PSNR_{(dB)}$	SSIM
Diffusion	13.6	0.04	75.35	55

Wavelet	14.94	0.04	76.78	42

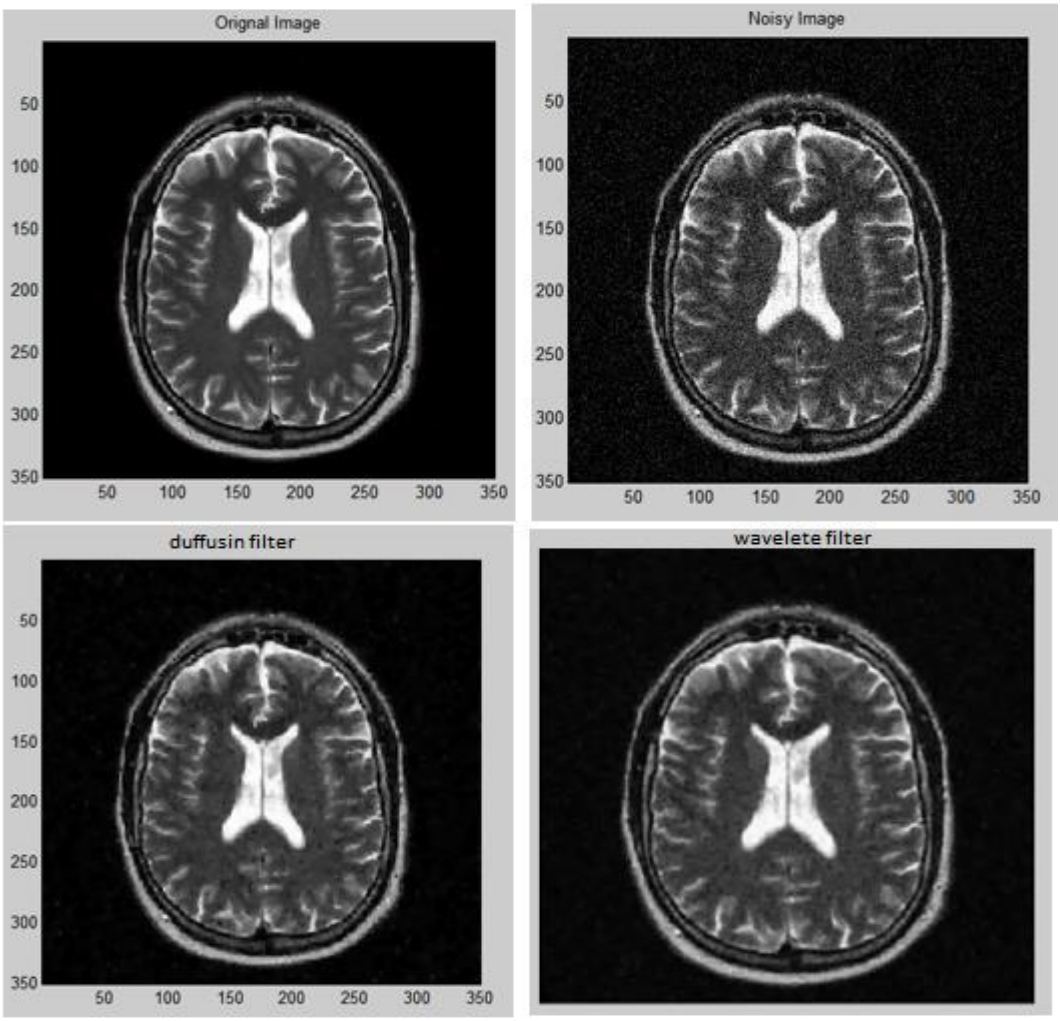

Figure 2: Sample Image 2

Table 3 summarized the quality performance measure of image number three. The performance of wavelet transforms filters overcome diffusion in SNR and PSNR. However, diffusion filter overcome wavelet transform in SSIM as giving index of 54 compared to wavelet transform which obtained 43 as shown in table.

Table 3- *Performance Measure of Image 3*

Metrics Filters	$SNR_{(dB)}$	RMSE	$PSNR_{(dB)}$	SSIM

Diffusion	14.06	0.04	75.88	54
Wavelet	15.12	0.04	77.07	43

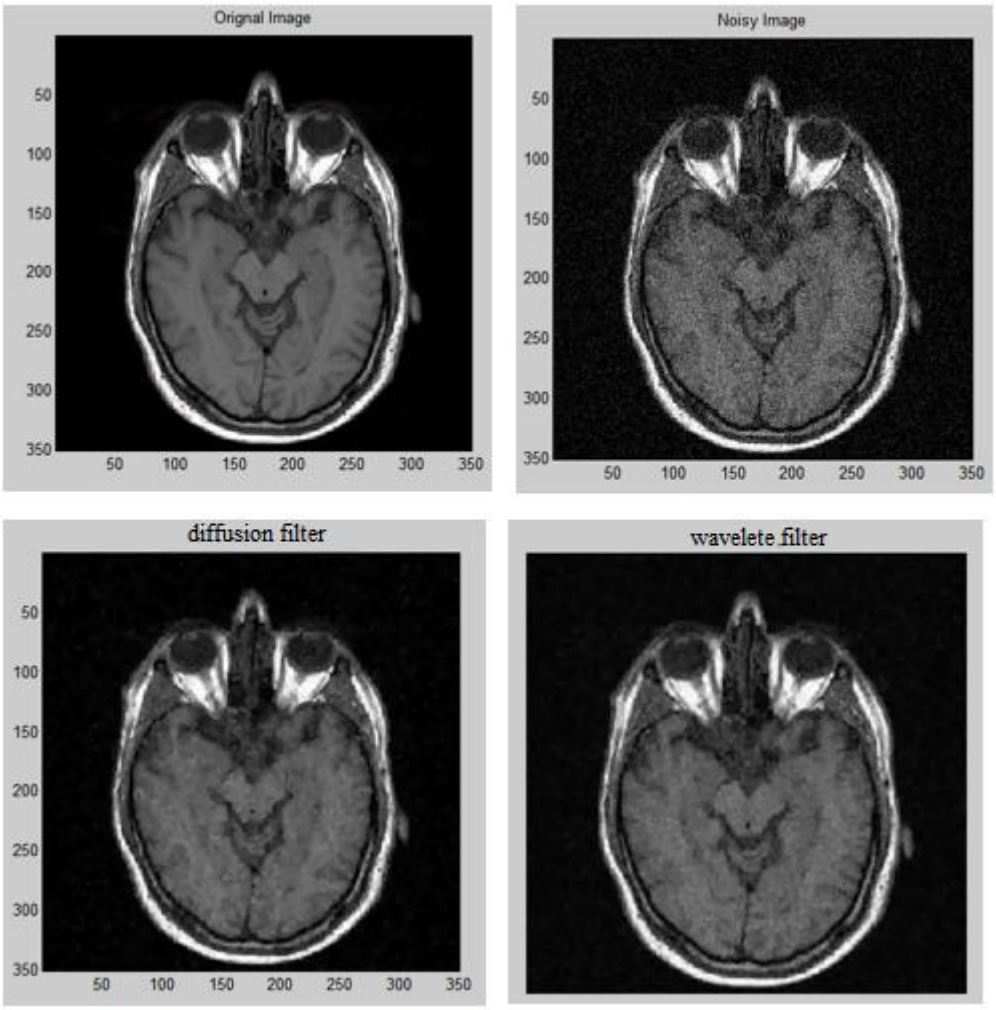

Figure 3: Sample Image 3

From the previous tables, the quality measure MSE of all the distorted images is similar in both diffusion and wavelet transform for most of the images, but the appearance or distortion level of each of the distorted image is different. Hence MSE image quality metric in medical image is not desirable. The output of the structural similarity index metrics in diffusion is better than the value obtained by wavelet

transform and this insures that, the diffusion filter is the best in denoising medical images image 3.

The traditional assessment methods, (signal-to-noise ratio, mean squared error, peak-signal-to noise ratio) shows that, wavelet filter overcomes diffusion filter in most of the images while diffusion overcome wavelet in image number three. However, the diffusion filter overcome wavelet transform by the proposed image quality assessment measured namely as (SSIM) in all the used database images. The noise measurement unit was in db. From this table, it can be concluded that, the diffusion is performed better than wavelet transform filter in enhancing the images and removing the noise at the same time image quality assessment measured show high value with diffusion compared to wavelet filter.

Conclusion

The study demonstrates the performance evaluation of the three algorithms for their noise removal capabilities and detail preservation are two conflicting goals that must carefully be taken into account in the design of any new filter. The nonlinear diffusion filter has received much attention and experienced significant developments, with promising results and applications in various specific domains. The elegant property of the technique is that it enhances images by reducing undesirable intensity variability within the objects in the image without losing any information and enhances the contrast of the edges. As can be seen in the results obtained by diffusion filter, the contrast of the images is very high and the structure of the images is same as the structure of the reference image which means no relocation occurred. Furthermore, the proposed diffusion filter was evaluated by several image quality assessments and it produced a result better than wavelet transform filter.

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