DENOISING ABNORMAL MRI IMAGES

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Abstract

Magnetic Resonance Image (MRI) is a medical imaging technique used in radiology to capture the anatomy and the physiological processes of the body. During this process, it gets affected by some unwanted noises like Gaussian noise, Salt and Pepper noise and Speckle noise. The removal of such noises from the actual MRI has been a hard nut to crack for researchers as it ultimately results in the formation of artifacts and causes blurred MR images. It is also considered a very vital step since it facilitates the analysis of the data of the image. There are many methods being used to remove or reduce noise.

This paper attempted to study two types of noise filtering techniques (Median filter and Wiener filter) on a noisy MRI intercepted by Salt and Pepper noise and Gaussian noise. Quality metrics such as MSE and PSNR were computed to evaluate the effectiveness of these two filters.

The results of the study noticed that it was the type of the filtering technique that decided the level removal or reduction of noise on these images. The researcher hopes that this result can be more useful in many medical diagnostics procedures and related applications.

Keywords: MRI; Noise; Gaussian; Median; Wiener; PSNR.

Introduction

The medical images are usually corrupted by frequent noise that takes place during the measurement process thus it complicate the automatic feature extraction and analysis of clinical data (Iza, et al, 2015). Medical images are collected by different kinds of sensors and hence they are contaminated by different types of noises, which have impact on image quality. Generally, speckle; Gaussian, salt and pepper noises mostly seen in the MRI, CT, and US images (Iza, et al, 2015; Senthilraja, et al, 2014). MR Image quality may get defective while capturing, processing and storing the MR image. Removing noise from the original MR images is still a tough task for researchers because noise removal introduces artifacts and causes blurring of the MR images (Hanafy, 2018). Noise causes undesirable effects such as artifacts, unrealistic edges, unseen lines, corners, blurred objects and disturbs background scenes. Noise removal is an important step in digital image processing. It is considered important

step to be taken before analyzing image data. In medical image processing multiple methods are used for noise reduction. Noise filters generally attempt to smooth the corrupted image by neighbourhood operations (Senthilraja, et al, 2014; Boyat and Joshi, 2015; Varnan, et al, 2011). It is necessary to apply an effective technique to compensate for data damage (Kharofa, 2018).

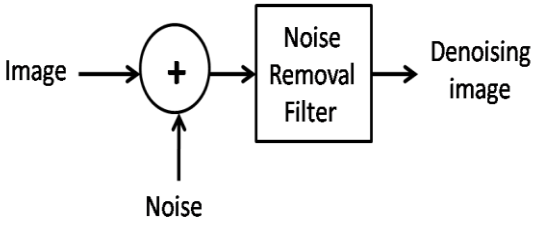

Figure (1): Denoising Image.

To measure the performance and image quality of the noise removal techniques, several parameters are available for the comparison. Common parameters are such as Peak Signal Noise Ratio (PSNR), Root Mean Squared Error (RMSE), Mean Squared Error (MSE) etc. (Senthilraja, et al, 2014) (varnan, et al, 2011).

Methodology

Two types of filters (median and wiener) filters are used to remove noise (Gaussian, and salt & pepper noises) from MRI images. This work has been conducted on sets of abnormal MRI images. The size of each image was (200 x 225) pixels. Filtering techniques algorithm were applied on these images after being corrupted by a given noise using MATLAB program environment. The Methodology structure is shown in Figure (2).

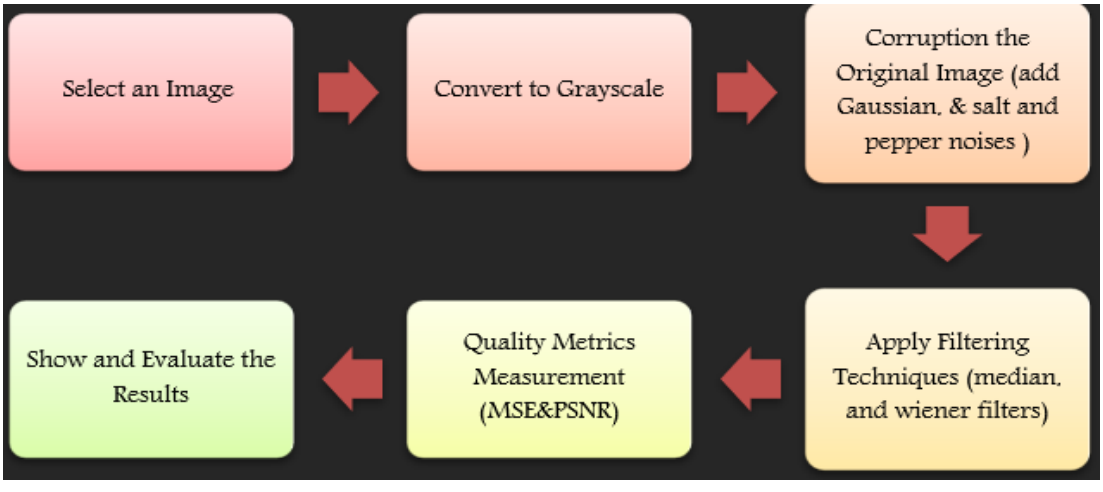

Figure (2) Methodology Structure.

To evaluate the performances of these filters, a comparison using statistical parameters of MSE and PSNR was computed. The MSE is the squared error averaged over the M × N array; where M and N represent the length and width of the image, respectively. This formula can be written as: (El Abbadi, et al, 2020) (Kaur, and Garg, 2011).

$$\boldsymbol{MSE = \frac{1}{NM}\sum_{i=1}^{M}\sum_{j=1}^{N}[f_1(i,j) - f_2(i,j)]^2} \qquad (\mathbf{1})$$

Where f_1 is output image and f_2 is input image, so the (RMSE)can be calculated as:

$$\boldsymbol{RMSE = \sqrt{MSE}} \qquad \boldsymbol{(2)}$$

Very low or close to zero of MSE indicates an excellent quality of image (Dass, and Yadav, 2020). The PSNR is a metric that is used to measure the similarity between two images. It, mainly, measures the quality of the restored image when it is corrupted due to noise and blur. It is the logarithmic function of the peak value of the image and the mean square error. This formula can be written as: (El Abbadi, et al, 2020; Kaur, and Garg, 2011).

$$\boldsymbol{PSNR = 10\ log\left(\frac{(255)^2}{MSE}\right)} \quad . \qquad (\mathbf{3})$$

Range of PSNR value is more or equal to zero, the best result is equal to infinity(El Abbadi, et al, 2020). For the PSNR being higher means excellent quality of image (Dass, and Yadav, 2020). The quality measurements were computed by using equations (1) and (3).

Results and Discussion

Two types of Filtering techniques (Wiener, and median) were implemented and applied on a set of noisy MRI image using MATLAB. Two types of noises: (Gaussian and Salt & Pepper noises) corrupted the set of MRI images. The results for these filtering techniques are illustrated in Figures (3), (4), (5) and (6). The simulation results obtained are represented visually. The viewers can be given their decision about the quality of each image.

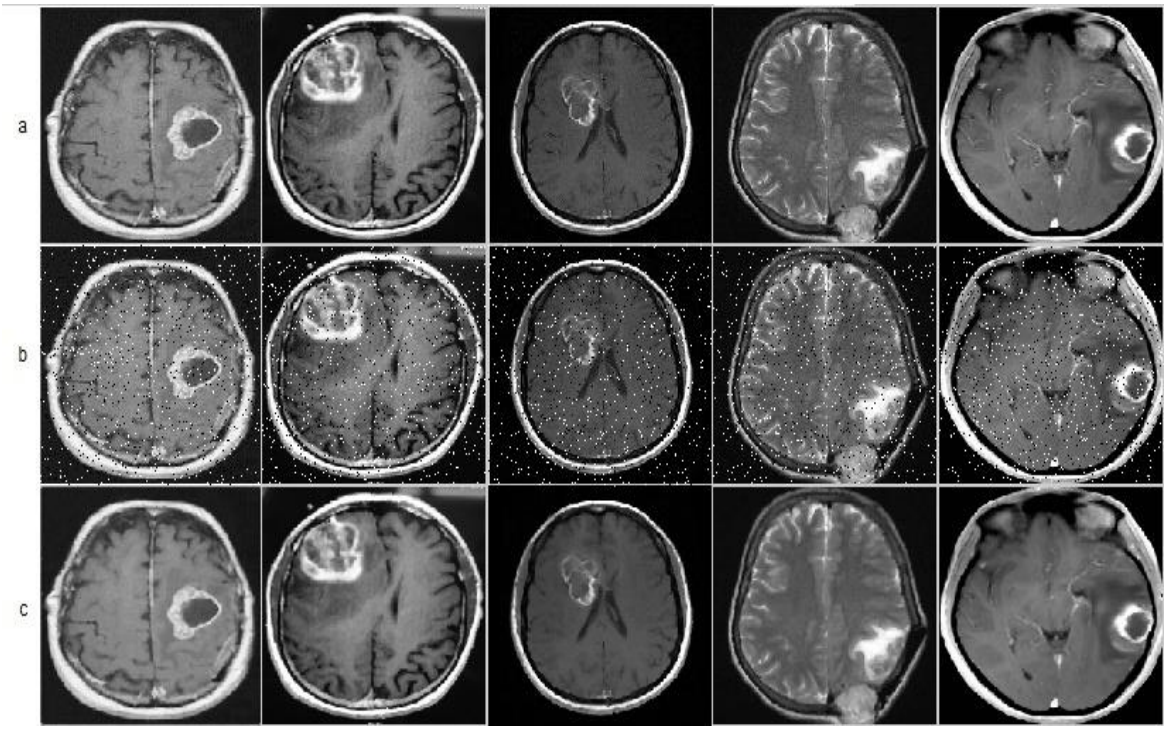

Figure (3): Salt & Pepper Noise Removing by Median filter ((a): Original Image. (https://www.kaggle.com/navoneel/brain-mri-images-for-brain-tumor-detection). (b): Noisy Images. (c): Filtered Images).

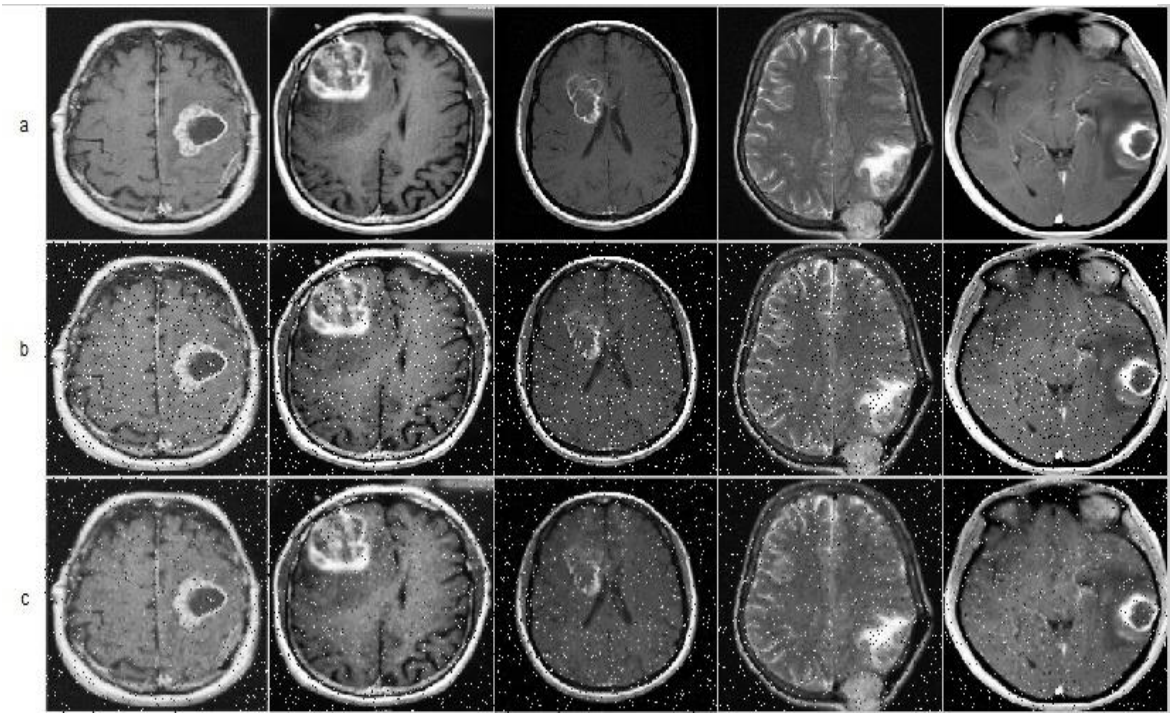

Figure (4): Salt & Pepper noise Removing by Wiener Filter:((a): Original Image, (b): Noisy Images, (c) Filtered Images).

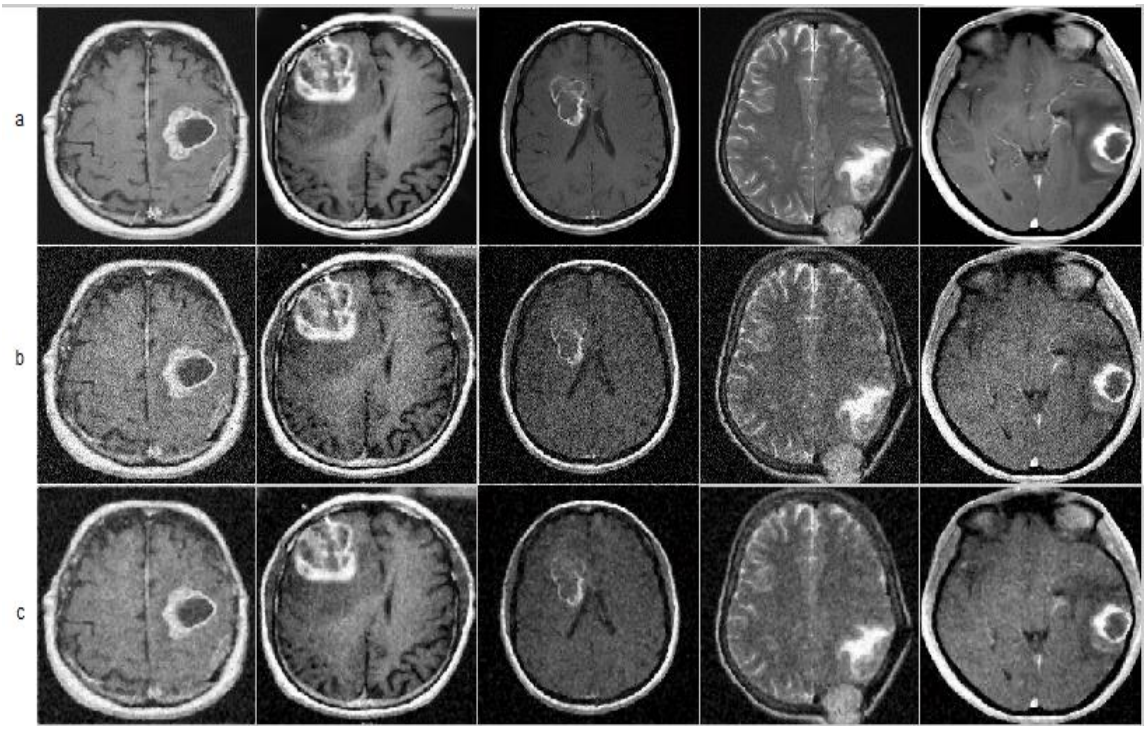

Figure (5): Gaussian Noise Removing by Median Filter: ((a): Original Image, (b): Noisy Images, (c): Filtered Images).

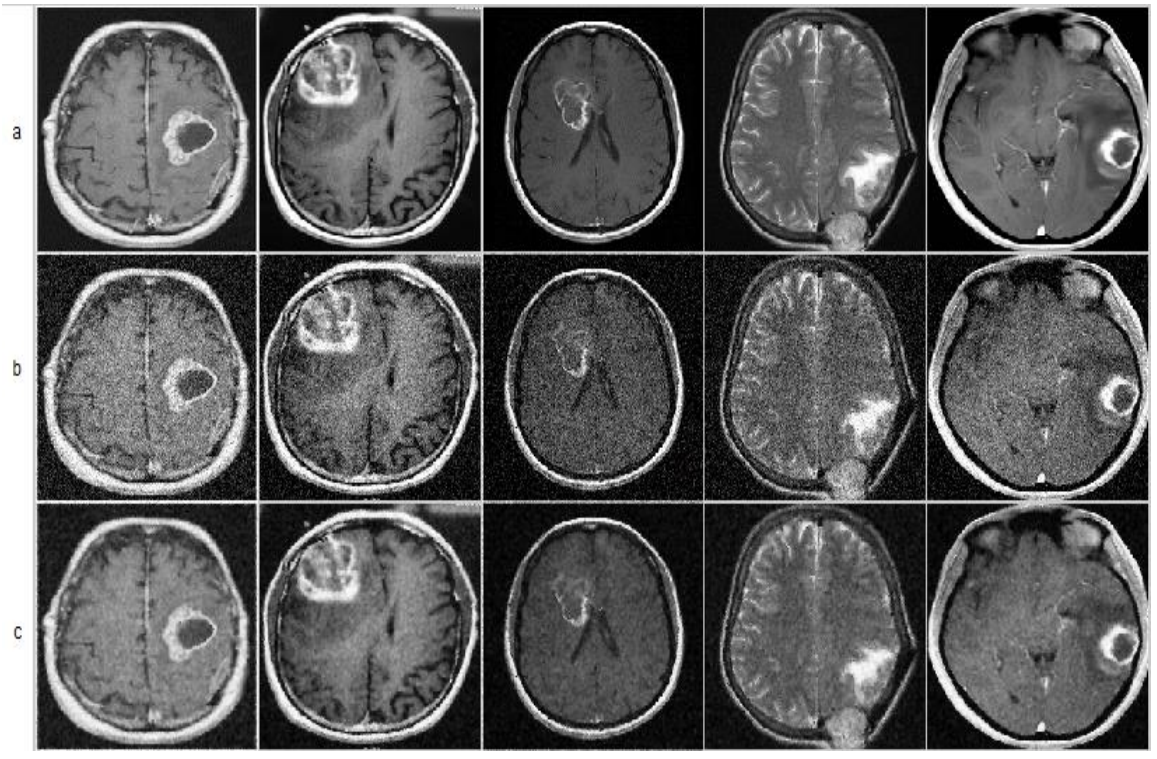

Figure (6): Gaussian Noise Removing by Wiener Filter: ((a): Original Image, (b): Noisy Images, (c): Filtered Images).

Figures (3), (4), (5) and (6) display the results for both filtering techniques that applied on the MRI images. The same MATLAB code is used for displaying the same arrangement for all sets of MRI images. Quality metric measurement, (MSE) and (PSNR) were calculated for both filtering techniques (Weiner and Median) filters by using equations (1) and (3) for all MRI images and tabulated in Table (1). The results of the Median filter in Figure (3) shows that it is better filter image quality for salt & pepper noise than Wiener filter shown in Figure (4). However, it provides a bad filter quality for Gaussian noise as shown in Figure (5). Whereas the Wiener results shows better filter quality for Gaussian noise than Median filter in Figure (6).

From Table (1) the PSNR records high values for each resultant image of Median filter results for Salt & Pepper noise, also PSNR records high values of Wiener for Gaussian noise. We have seen that the (PSNR) for each image has been completely different from the other; these results show that the variance of the properties of each image is completely different.

Table (1): (PSNR) Values of Filtering Techniques.

Images	Salt & Pepper Noise		Gaussian Noise	
	Median	**Wiener**	**Median**	**Wiener**
image1	25.93	20.97	23.55	25.90
image2	29.07	20.25	25.16	26.11
image3	19.21	19.07	18.85	25.53
image4	29.62	19.88	25.49	26.28
image5	30.60	20.18	26.01	26.12

To sum up, Median filter works better for salt & pepper noise as shown in Figure (3) and Table (1) whereasWeiner filter works better for Gaussian noise as shown in Figure (6) and Table (1). Moreover, Median filter performs higher PSNR compared to Weinerfilter for salt & pepper noise. However, Median filter is inefficient in removing Gaussian noise; more blurring occurs in the image as shown in Figures (4), (5)and Table (1).

Conclusions

This study identified that the Median filter plays an effective role in discarding salt & pepper noise and Weiner filter is effective in removing Gaussian noise. It was also noticed that the filtering technique employed determined the level of denoising when processing medical images. The denoising of MRI images performance depends on the type of noise and type of filtering techniques. Hence, it is believed that the output of this study can be beneficial in multiple applications related to the medical diagnostics.

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