Comparative Study on De-Noising the MRI images for Alzheimer's disease

[1]Dr.Aziz Makandar, [2]Smt.Rashmi Somshekhar,
[1][2] Akkamhadevi Women's Universiy,Vijayapura

Abstract*—In medical imaging de-nosing of the images plays an important role in analyzing the images. Now days there are many imaging modalities available for identifying the disease. The MRI imaging modality is one which is used to identify the Alzheimer's disease. Due to transmission error, while capturing and storing the images the images are liable to find some common noises like Gaussian noise, salt and pepper noise and speckle noise where it is difficult to trace out the region of interest for the diagnosis of the disease. So, it's important to de-noise the images for proper identification of the diseases and for the further treatment plans. The study shows the comparative analysis of different noises added to the MR images of Alzheimer's disease and noise removed by using the de-noised techniques. We have, considered all the two common noises present in the MRI images and the two filtering techniques like median and wiener filters which are commonly used in medical images for de-noising the image. The results are compared with the PSNR values.

Index Terms— **Alzheimer's disease, MRI images, Gaussian noise, salt and pepper noise, median filter and wiener filter.**

I. INTRODUCTION

Medical imaging plays important role in diagnosing the disease and for further treatment plan. For the diagnosis there are many imaging modalities that includes CT scan, MRI, fmri, PET, spect, EEG, Ultrasound etc which functions differently for the identification of the disease. Alzheimer's disease is a kind of neurological disorder in which a person suffers from memory loss and cognitive decline due to death of the brain cells [5]. In image acquisition some of the unwanted information is present that will be removed by several preprocessing techniques. Filtering helps to enhance the image by removing noise [7]. Most preferable imaging technique for the brain scan is MRI imaging .Which is often contaminated with the noise like speckle, Gaussian and impulse noise. These noises will degrade the quality of the image and would be difficult to trace the region of interest. This is still a challenging task for the researcher in the field of medical imaging. There are many de-noising techniques for the preprocessing of the images and for further enhancement. The different filtering techniques that are used to de-noise the images are median filter and wiener filter. These works on de-noising of the images based on the kind and amount of the noise present in the images. This study considers the MRI images of Alzheimer disease for the study. The Alzheimer disease (AD) is a neurodegenerative disease which stands third as the cause of the death after heart attack and cancer. The neurons gets degenerated which ultimately leads to brain death. There are different regions affected by the AD in the brain one which gets first affected is the hippocampus region which is responsible for the memory. The study considers AD affected MRI T2 sequence image from ADNI. The Data used for the work is obtained from (http://www.loni.ucla.edu/ADNI) Alzheimer's disease neuroimaging Initiative (ADNI) database [3].

Common noises in MR image

From theoretical expectations, the noise measured in unaltered MR images was found to be usually distributed, spatially invariant and white. As in MR image processing, the MR images .High-Resolution Neuroimaging - Basic Physical Principles and Clinical Applications are much sensitive to noise which results are due to the image acquisition errors and transmission errors. MR images captured usually are prone to Gaussian noise and salt and pepper noise which has influence on the MR image quality. Poor quality of MR image tends to degrade the performances of any works such as feature extraction, reduction and classification of the processed MR images. The noises go to be removed before these processing stages as there were many available MR image filtering algorithms recommended in the literature. Gaussian noise and Impulse noise are popular noises distributed in magnitude MR images and non-avoidable. Because of its mathematical tractability in both the spatial and frequency domains, many of filters are used to remove the Gaussian noise. Salt and pepper noise consider as impulsive noise will have dark pixels and bright pixels alternate bright and dark regions. Because impulse corruption usually is large compared with the strength of the image signal, the impulse noise mostly is digitized as extreme values in an image.

Gaussian noise or amplifier noise

It is conjointly referred to as Gaussian distribution. The Gaussian noise has a probability density equation of the normal distribution. The Gaussian noise or amplifier noise is added to MR image during image acquisition such as sensor noise caused by low light, high temperature, transmission e.g. electronic circuit noise. This noise will be removed by using spatial filtering (Adaptive Wiener filter, Median filter, Wiener filter and Adaptive Median filter). The Probabilities Density Function (PDF) of Gaussian Noise is shown in the following equation.

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (1)$$

where P(x) is the Gaussian distribution equation noise in MR image; μ and σ is the mean and standard deviation respectively.

Impulse noise.

The Impulse noise is also denied by Salt & Pepper noise or Spike noise. It is caused by malfunctioning pixels in camera sensors, faulty memory locations in hardware, or transmission in a noisy channel. It is forever independent and uncorrelated to MR image pixels. Its two types are the salt-and-pepper noise and the random-valued noise. In the Salt and Pepper type of noise, the noisy pixels takes either salt value (gray level − 225) or pepper value (gray level − 0) and it seems as black and white spots on the MR images In case of random valued impulse noise, noise can take any gray level value from 0 to 225. In this case also noise is randomly distributed over the entire MR image and probability of occurrence of any gray level value as noise will be same. The Salt and Pepper noise is shown in following equation 2.

$$P(z) = \begin{cases} P_a & \text{for } z = a \\ P_b & \text{for } z = b \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

2. Filtering techniques

The aim of filtering techniques is used to reduce noise and improve the visual quality of the image. Below filtering techniques used in medical imaging applied on MRI images.

Median Filter:

Median filter is a nonlinear method .It is used to remove noise from images and for preserving edges. It is mainly used for removing salt and pepper type of noise. The median filter works by moving the pixel by pixel in the image by replace each value with the median value of the neighboring pixel. The pattern of neighbors is called the "window", which slides, pixel by pixel over the entire image 2 pixels, over the entire image. The median value is calculated by sorting all the pixels values from the window into numerical order and then replacing the pixel being considered with the middle (median) pixel value[4],[5]. Below figures shows the images with applied Gaussian noise and salt and pepper noise to the original image and then the images are filtered.

Wiener Filter:

The important use of wiener filter is to reduce the amount of noise present in an image by comparison with an estimation of the desired noiseless signal. It is based on a statistical approach to achieve the noise free image. Before implementing wiener filter it is assumed that user knows the spectral properties of the original image and noise. The aim of the process is to have minimum square error. That is, the difference the original signal and the new signal should be less as possible. The equation of the wiener filter in frequency domain as W (u, v).The restored image is given by equation

$$Xn(u, v) = W(u, v).Y(u, v) \quad (3)$$

Where Y (u,v) is the received signal and Xn (u,v) is the restored image. The approach of reducing degradation at a time induces to develop a restoration algorithm. The Wiener filtering executes an optimal tradeoff between inverse filtering and noise smoothing [1], [2], [3]. It removes the additive noise and inverts the blurring simultaneously. The below MRI images shows the noisy image with salt and pepper noise and the wiener filtered image.

II. Analysis:

The below figures show the Gaussian and salt n pepper noises on the MRI images of AD with different filters.

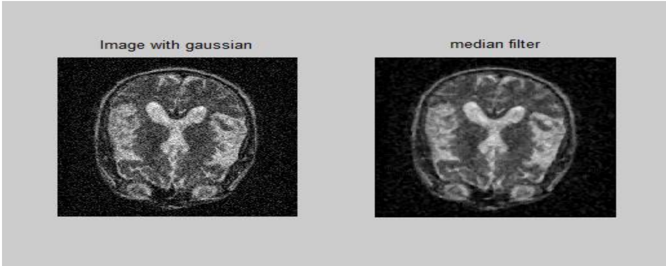

Fig.1. Shows the image with Gaussian noise and median filtered applied.

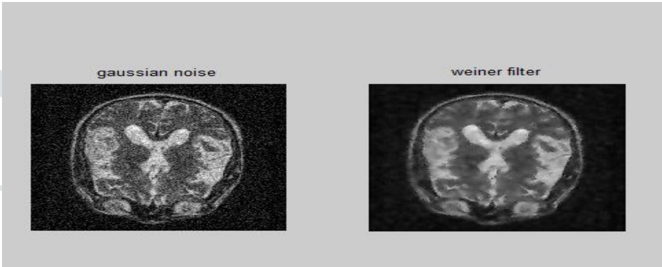

Fig.2. Shows the images with Gaussian noise and Weiner filter.

The above figure show that the Weiner filter work good for the Gaussian noise applied on MRI of AD images.

The below figures show the salt n pepper noises on the MRI images of AD.

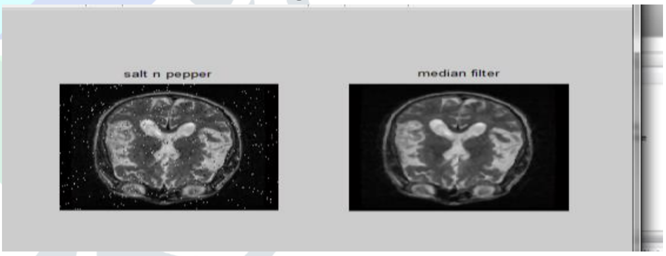

Fig.3. Shows the images with Salt n pepper noise and Median filter

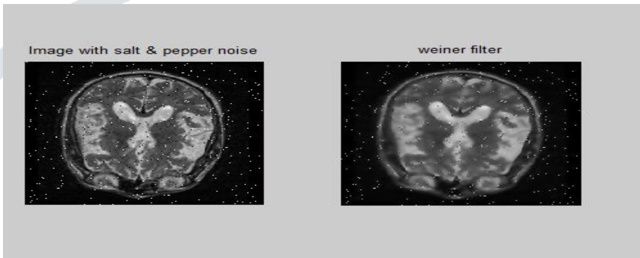

Fig.4. Shows the images with salt n pepper noise and Weiner filter.

The above figure show that the Median filter work good only for salt n pepper noise applied on MRI of AD images.

III. Experimental Results

The work is done with the comparison of different filtering techniques and the results are computed with the different values of PSNR as shown in the given table. Also the graphical representation shows the variations of the values. In the (PSNR) peak signal to noise ratio the peak value possible for any one pixel or element is taken and then the values are computed by using the equation.

snr=10*log10((imaximum -iminimum)./mse) (3)

The results show the higher PSNR values for the good quality of the images. Different filtering techniques when compared the median filter technique is considered to be the good filtering technique for the AD MRI images. Table1 and table2 gives the computational results of PSNR values and the figure7 and figure8 shows the graphical representation of PSNR values for different filters.

Table 1. PSNR values for the different filtering techniques with image resolution 2048x2048.

Sl.No	Images with Gaussian noise	Wiener Filter	Median Filter
1	ADT2	17.7891	18.0641
2	AD1T2	19.046	19.1513
3	AD2T2	17.68	17.9535
4	AD3	18.4793	18.4974
5	AD3T2	19.2439	19.1276
6	AD4T2	19.1954	19.2226
7	AD5T2	18.8025	18.7008
8	AD6T2	18.2477	18.2542
9	AD7T2	18.9177	18.7968
10	ADT3	19.0227	18.8462
11	6AD6T2	18.1879	18.1085
12	6AD7T2	18.7136	18.7641
13	6AD8T2	18.9192	18.9915
14	AD	19.0453	19.2861
15	13AD	19.119	19.0989
16	39AD	19.1358	18.8199
17	303AD	19.1616	19.08
18	179AD	18.9637	18.8059
19	MCI3	16.291	16.1918
20	MCI4T2	19.2424	18.9751

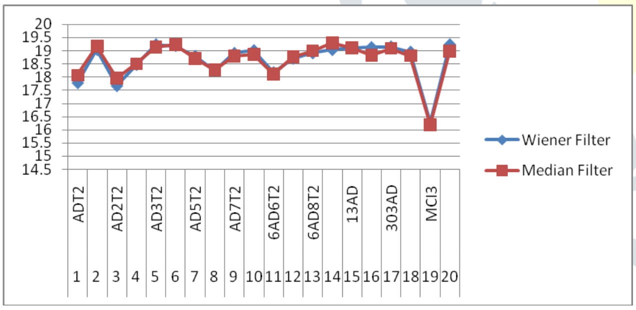

Fig.5. Shows the graphical representation of PSNR values for the Gaussian noise.

Table 2. PSNR values for the different filtering techniques with image resolution 2048x2048.

Sl.No	Images with Salt n Pepper noise	Median Filter	Wiener Filter
1	ADT2	22.663	22.663
2	AD1T2	22.552	22.0423
3	AD2T2	22.9591	23.3903
4	AD3	22.5606	22.3304
5	AD3T2	22.9315	22.4343
6	AD4T2	22.563	22.0496
7	AD5T2	22.8962	22.8196
8	AD6T2	22.7917	23.1041
9	AD7T2	22.8848	22.6082
10	ADT3	22.3381	21.9646
11	6AD6T2	22.7756	23.1041
12	6AD7T2	22.6963	22.6082
13	6AD8T2	23.2671	23.1573
14	AD	23.9954	24.3376
15	13AD	24.0022	24.3376
16	39AD	23.6419	24.2132
17	303AD	24.2158	24.1109
18	179AD	24.3334	24.5513
19	MCI3	23.0414	23.3733
20	MCI4T2	23.0445	22.9571

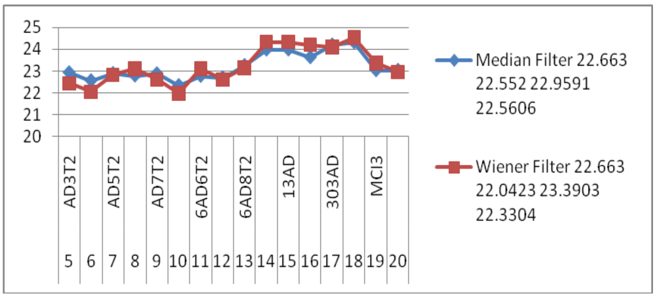

Fig.6. Shows the graphical representation of PSNR values for the salt n pepper noise.

CONCLUSION

The work carried out in this paper discuss about noises models like salt n pepper noise and Gaussian noise with different filtering techniques which includes median filter and wiener filter. To bring out the differences for the kind of filters that works better for the kind of noise applied on the MRI images of Alzheimer's disease. Image processing allows different algorithms to be applied on the input data to avoid the noise, distortion etc during processing of the images. We are working on T2 sequence MRI images of Alzheimer's disease. The images of Alzheimer disease are pre processed by removing noise like Gaussian noise and Salt & Pepper noise by using two filters median and wiener filter which are popularly used in biomedical images for removing the particular kind of noise. Further the results have been computed and compared by using the PSNR values for the different noise of AD images. Through this work we can find that, the choice of filter depends upon the type and amount of noise present in an image. Also, the de-noising the MRI images performance depends on the type of noise and type of filtering techniques.

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