VARIOUS FILTERING APPROACHES USED IN MRI MEDICAL IMAGES

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ABSTRACT Image processing has made a significant progress in the quantifiable analysis of biomedical images over the last 2 decades. The main objective of this paper is to give comparison on existing methods of filters and highlight the best method to retrieve similar MRI brain image. I am presenting an overview of different filtering technique which is applied to classify the brain images. This paper also includes equations on the filtering method with similar matching algorithms We applied two techniques of weiner filter to get in an output: one is by using median filter and the other by mean filter to remove the noise from an image, the results we got from median filtering is BLF-M1and from mean filtering is BLF-M2. This experimental analysis will improve the accuracy of MRI-brain images for easy diagnosis. The results, which we have achieved, are more useful and they prove to be helpful for general medical practitioners to analyse the symptoms easily.

Keywords – *Weiner; Mean (Average filter), Median; Gaussian; Speckle noise; Gaussian; Salt and Pepper; Peak Signal toNoise Ratio (PSNR), Mean SquareError (MSE) RMSE (Root Mean Square error).*

I.INTRODUCTION

An image is often degraded by noise in acquirement or transmission.Noise appears in image from a variety of sources. The objective of de-noising is to eliminate the noise by retainingthe important signal features. De-noising can be done through filtering. In this paper we can see how different types of noise will affect the quality and the information in images. The main objective of this paper is to study the image filtering methods applied on images to remove the different types of noise whilecapturing ortransmission.A detailed comparison is provided by *Peak Signal toNoise Ratio (PSNR), Mean SquareError(MSE), SNR, RMSE.*

II.TYPESOFNOISE

POISSON NOISE

Poisson noise is a noise which is also known as shot noise. It is a type electronic noise. Poisson noise occur under the situation where there is a statistical fluctuations in the measurement caused wither due to finite number of particles like electron in an electronic circuit that carry energy, or by the photons in an optical device[10], [14].

SPECKLENOISE

The Speckle noise is a noise which degrades the quality of an image. Speckle noise tends to damage the image being acquired from the active radar as wells as synthetic aperture radar (SAR) and Magnetic Resonance Imaging (MRI). If Speckle Noise is present in the conventional radar results from random variations in the return signal from an object which is no longer image process signal increases the mean grey level in an image [10]

Speckle Noise follows a gamma distributionand isgiven as:[1]

(g) = [∝−1 (∝−1)! ∝ e−]

Where, ∝ is the shape parameter of gamma distribution, 'a' is the variance and 'g' is the gray level [1].

GAUSSIAN NOISE

Gaussian noise is statistical noise that arises during acquisition having a probability density function (PDF) equal to that of the normal distribution, which is also known as the Gaussian distribution. In other words, the values that the noise can take on are Gaussian- distributed[14].

SALT PEPPER NOISE

Salt and pepper noise is a generalized noise in images. In an image the noise itself represents as randomly occurring white and black pixels.An effective noise reduction algorithm for this type of noise involves the usage of a median and morphological filter. [10],[1]. This type of noise can be caused by malfunctioning of analog-to-digital converter in cameras, bit errors in transmission etc... An image which contains Salt Pepper noise will generally have bright pixels in dark portion and dark pixels in bright portion of the image. The image which is low in quality has bright and dark pixels present in it which causes noise in it also referred as Salt Pepper noise.

LOCAL VAR NOISE

Local Var noise adds zero-mean, Gaussian noise to an image I, where the local variance of the noise var is a function of the image intensity values in I. The image intensity and arguments are vectors of the same size, and plot (image, intensity, var) plots the functional relationship between noise variance and image intensity. The image intensity vector must contain normalized intensity values ranging from 0 to 1.[1],[14]

III.TYPES OF FILTER

MEDIAN FILTER:

The best know order statistics is the median filter, which, as its name implies, replaces the value of a pixel by the median of the grey levels in the neighbourhood of that pixel [1][13].

$$\hat{f}(x,y) = \frac{1}{mn} \sum_{(s,t)\in S_{xy}} g(s,t)$$

The original value of the pixel is included in the computation of the median. Median filters are quite popular because, for certain types of random noise, they provide excellent noise reduction capabilities, with considerably less blurring than linear smoothing filters of similar size. Median filter yields excellent results for images corrupted by this type noise.

MEAN FILTER

Therearetwo typesoffilteringschemes namely linearfiltering and nonlinear filtering [7]. TheMean Filter appliesmaskovereach pixel in the signal. Eachof thecomponentsofthepixelscomes under themarebeingaveragedtogethertoform a single pixelthat's why the filter is otherwise knownas averagefilter.[14]Mean filter is mainly suitable for eliminating grain noise from an image. As each pixel gets summed the average of the pixels in its neighborhood is found out, local variations caused by grain noise are reduced significantly by replacing it with average value. Some of mean filters are:[1]

1. Geometric Mean filters:

Geometric Mean filter achieves smoothing comparable to the arithmetic mean filter the amount of detail lost in the geometric mean filtering is lesser than the arithmetic mean filtering.[1]

$$\hat{f}(x,y) = \left[\prod_{(s,t)\in S_{xy}} g(s,t)\right]^{1/mn}$$

2. Harmonic mean filter:

The harmonic mean filter can be used to remove noises such as salt and Gaussian noise but it cannot be used for pepper noise.[1]

$$\hat{f}(x,y) = \frac{mn}{\sum_{(s,t)\in S_{xy}} \frac{1}{g(s,t)}}$$

3. Contraharmonic mean filter:

The contraharmonic mean filter is used to salt and pepper noise.[1]

$$\hat{f}(x,y) = \frac{\sum_{(s,t)\in S_{xy}} g(s,t)^{Q+1}}{\sum_{(s,t)\in S_{xy}} g(s,t)^{Q}}$$

GAUSSIAN FILTER:

Gaussian filters isa class of linear smoothing filters with the weights chosen according to the shape of a Gaussian function. The Gaussian kernel is widely used for smoothing purpose. The Gaussian smoothing filter is very good filter for removing noise drawn from a normal distribution[14][1].

Some properties of Gaussian filter are:
i) The Fourier transform of a Gaussian function is itself a Gaussian function. The Fourier transform of a Gaussian has a single lobe in the frequency spectrum. Images are often corrupted by high-frequency noise, and the desirable feature of the image will be distributed both in the low-and-high frequency spectrum.
ii) The degree of smoothing is governed by varianceσ. A largerσ implies a wider Gaussian filter and greater smoothing.[13]

Gaussian Low pass filter has the transfer filter

$$H(u,v) = e^{-D^2(u,v)/2\sigma^2)}$$

Where σ – measure of the Gaussian curve spread

$$D(u,v) = \sqrt{(u - M/2)^2 + (v - N/2)^2}$$

Gaussian High pass filter has the transfer filter

$$H_{hp}(u,v) = 1 - H_{lp}(u,v)$$

WIENER FILTER

The wiener filter tries to build an optimal estimate of the original image by enforcing a minimum mean-square error constraint between estimate and original image. The wiener filter is an optimum filter. The objective of a wiener filter is to minimise the mean square error. A Wiener filter has the capability of handling both the degradation function as well as noise.[1][14]

Minimum mean square error filtering (Wiener)

$$e^2 = E\{(f - \hat{f})\}$$

$$\hat{F}(u,v) = \left[\frac{H*(u,v)s_f(u,v)}{s_f(u,v)[H(u,v)]^2 + s_n(u,v)}\right]G(u,v)$$

$$= \left[\frac{H*(u,v)}{[H(u,v)]^2 + s_n(u,v)/s_f(u,v)}\right]G(u,v)$$

$$\left[\frac{1}{H(u,v)}\frac{\lfloor H(u,v)\rfloor^2}{\lfloor H(u,v)\rfloor^2+s_n(u,v)/s_f(u,v)}\right]G(u,v)$$

$H(u,v)$ = degradation function

$H*(u,v)$ = complex conjugate of $H(u,v)$

$\lfloor H(u,v)\rfloor^2 = H*(u,v)H(u,v)$

$s_n(u,v) = \lfloor N(u,v)\rfloor^2$ = power spectrum of the noise

$s_f(u,v) = \lfloor F(u,v)\rfloor^2$=power spectrum of the undegraded image.[1].

$$\hat{F}(u,v) = \left[\frac{1}{H(u,v)}\frac{\lfloor H(u,v)\rfloor^2}{\lfloor H(u,v)\rfloor^2 + K}\right]G(u,v)$$

AVERAGING FILTERS (Smoothing Liner Filter)

Linear spatial filter is simply the average of the pixels contained in the neighborhood of the filter mask. These filters sometimes are called averaging filters.[14] A major use of averaging filters is in the reduction of "irrelevant" detail in an image. By 'irrelevant" we mean pixel regions that are small with respect to the size of filter mask. A spatial averaging filter in which all coefficients are equal is sometimes called as a box filter. [9].

BLF M1 FILTER:

These BLF M1 techniques are the wiener filter to get in an output: one is by using median filter to eliminate the noise from an image, the outcome we got from median filtering is BLF-M1. This type of analysis provides the accurate resultsfor easy diagnosis of MRI-brain images.

Input of noise image I(x,y)→Wiener filter→

→output of WF image OUT(x,y)→

→Input of I(x,y)→Median filter→Denoise Image

BLF M2 FILTER:

These BLF M2 techniques are the wiener filter to get in an output: one is by using mean filter to remove the noise from an image, the results we got from mean filtering is BLF-M2. From this experiment accurate results are obtained for easy diagnosis of brain images.

Input of noise image I(x,y)→Wiener filter→

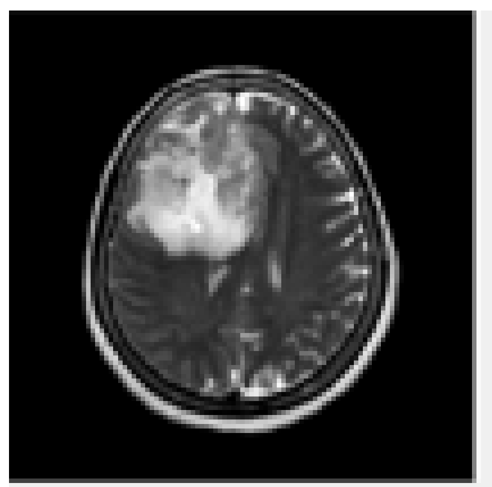
→output of WF image OUT(x,y)→

→Input of I(x,y)→Mean filter→Denoise Image

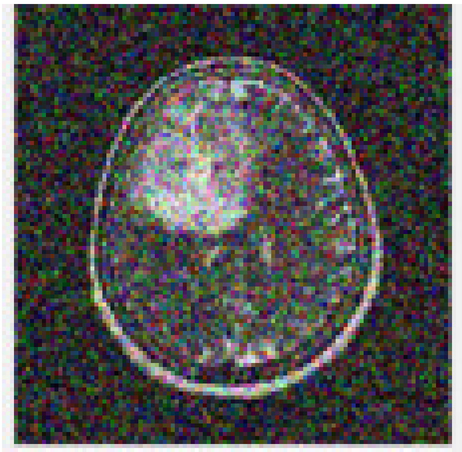
IV.EXPERIMENTAL RESULTS

SIMULATION OBTAINED:

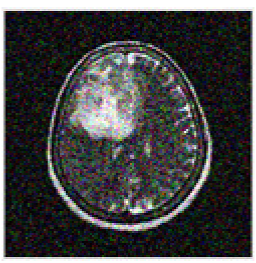
Figure 1: Gaussian Noise with Median, Wiener, Average, Gaussian, Mean, BLF-M1, BLF-M2 Filters.



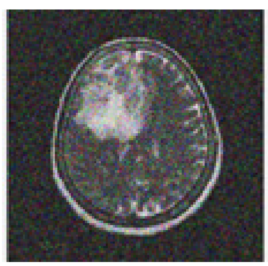
A) Original MRI image



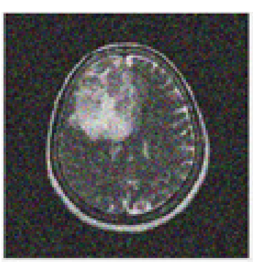
A.1. image with Gaussian noise



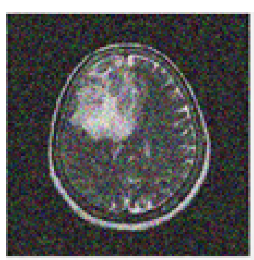
A.1.1) Median Filter



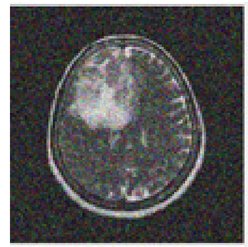
A.1.2) Wiener Filter



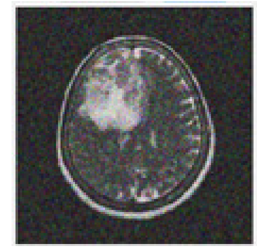
A.1.3)Average Filter



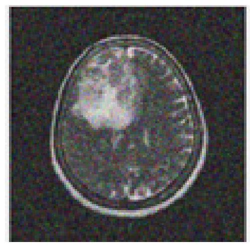
A.1.4)Gaussian Filter



A.1.5)Mean Filter

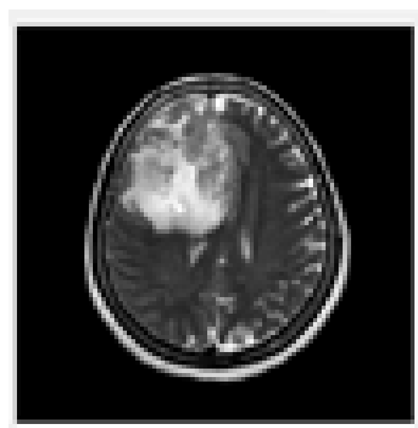


A.1.6)BLF-M1 Filter

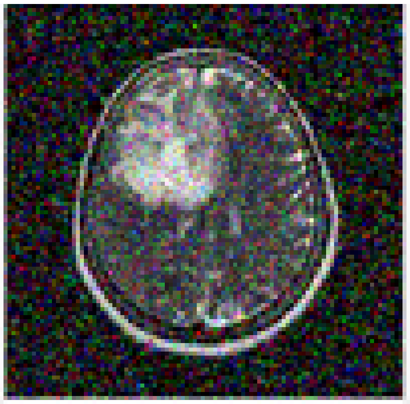


A.1.7) BLF-M2 Filter

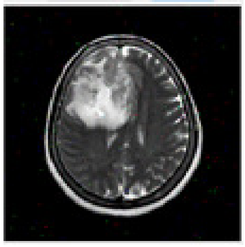
Figure 2:Salt&Pepper Noise with Median, Wiener, Average, Gaussian, Mean, BLF-M1, BLF-M2 Filters.



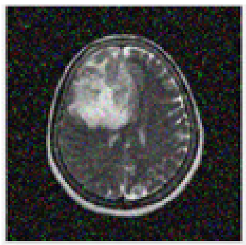
B) Original MRI image



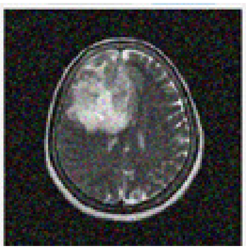
B.2 Salt&Pepper Noise



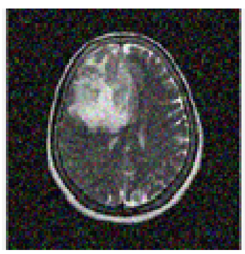
B.2.1)Median Filter



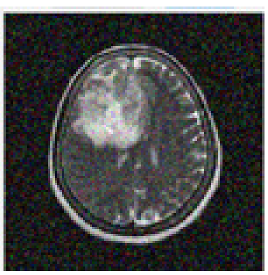
B.2.2)Wiener Filter



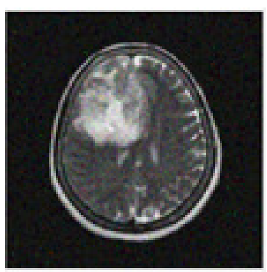
B.2.3)Average Filter



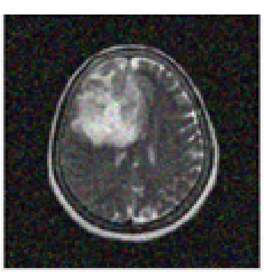
B.2.4)Gaussian Filter



B.2.5) Mean Filter

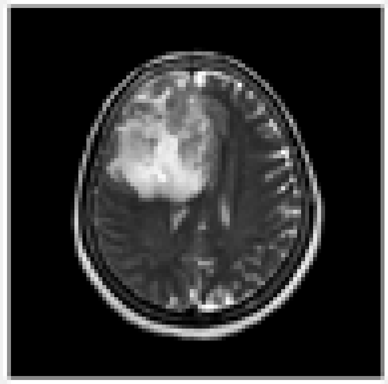


B.1.6) BLF-M1 Filter

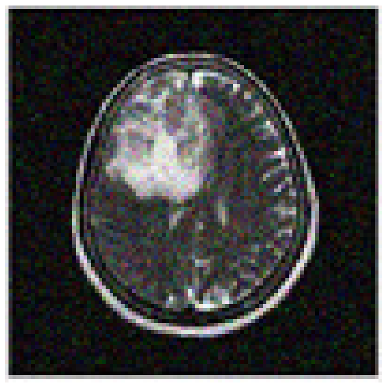


B.1.7) BLF-M2 Filter

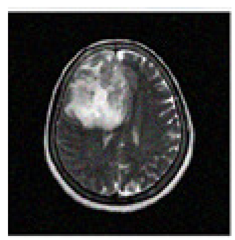
Figure 3:LocalvarNoise with Median, Wiener, Average, Gaussian, Mean, BLF-M1, BLF-M2 Filters.



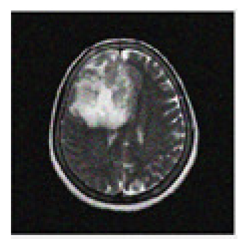
C) Original MRI image



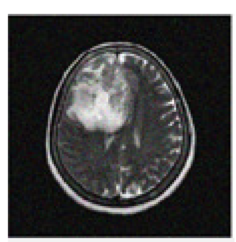
C.3) Localvar Noise



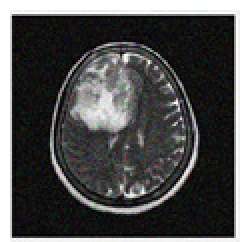
C.3.1) Median Filter



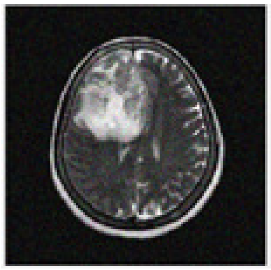
C.3.2) Wiener Filter



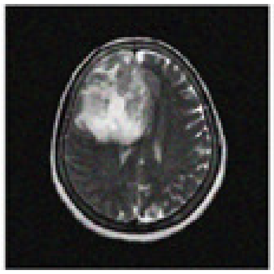
C.3.3)Average Filter



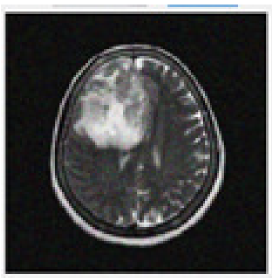
C.3.4)Gaussian Filter



C.3.5) Mean Filter

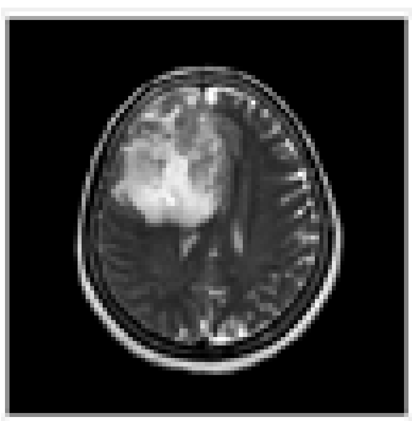


C.3.6) BLF-M1 Filter

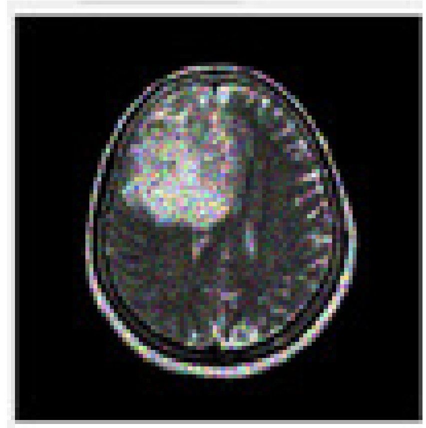


C.3.7) BLF-M2 Filter

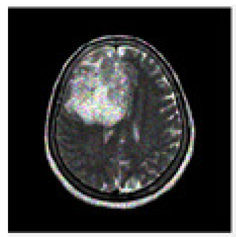
Figure 4: Speckle Noise with Median, Wiener, Average, Gaussian, Mean, BLF-M1, BLF-M2 Filters.



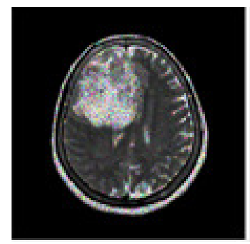
D) Original MRI image



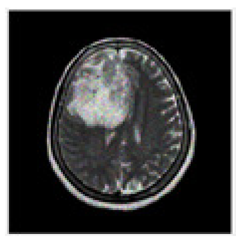
D.4)Speckle Noise



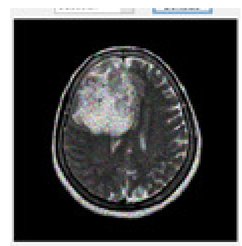
D.4.1) Median Filter



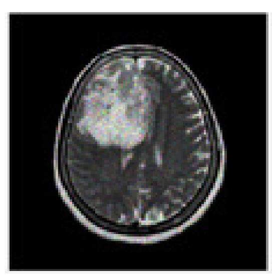
D.4.2) Wiener Filter



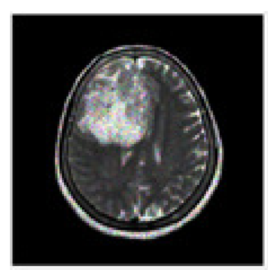
D.4.3) Average Filter



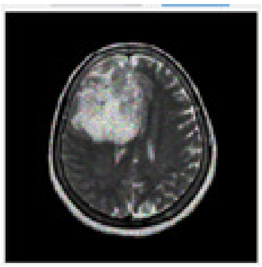
D.4.4) Gaussian Filter



D.4.5) Mean Filter

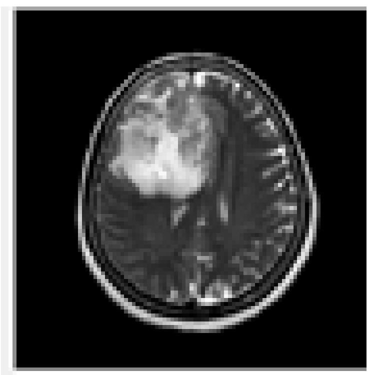


D.4.6) BLF-M1 Filter

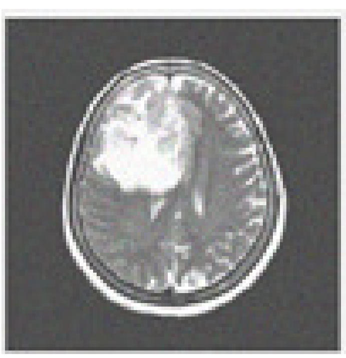


D.4.7) BLF-M2 Filter

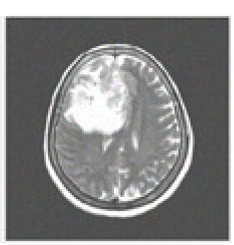
Figure 5:Poisson Noise with Median, Wiener, Average, Gaussian, Mean, BLF-M1, BLF-M2 Filters.



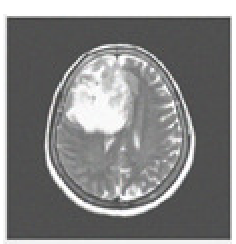
E) Original MRI image



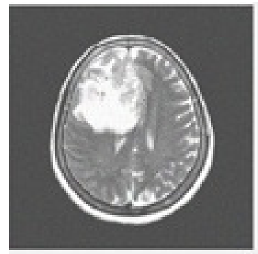
E.5) Poisson Noise



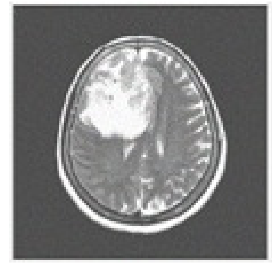
E.5.1) Median Filter



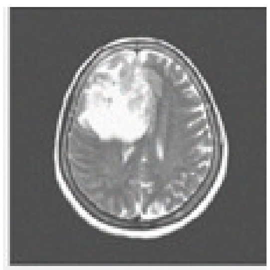
E.5.2) Wiener Filter



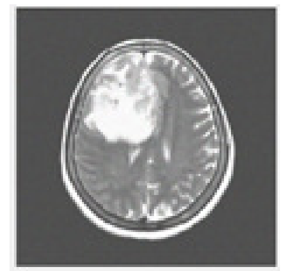
E.5.3) Average Filter



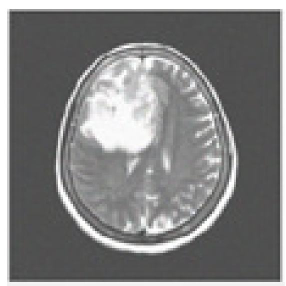
E.5.4)Gaussian Filter



E.5.5) Mean Filter



E.5.6) BLF-M1 Filter



E.5.7) BLF-M2 Filter

V.RESULTS ANALYSIS

The performance analysis of different filter for different types of noises is quantized through Mean Square Error (MSE) value, RMSE value, SNR value, MD value and Peak to Signal Noise Ratio (PSNR) value.

Figure 1:Gaussian Noise with different types of filtering technique:

S.NO	TYPEOF NOISE	FILTER	MSE	PSNR	SNR	RMSE	MD
1.	Gaussian	Median	4.1716e+03	16.7330	5.2376	64.5880	11.7546
2.	Gaussian	Wiener	5.676e+03	15.3959	3.9006	75.3364	31.3206
3.	Gaussian	Averaging	5.9407e+03	15.1976	3.7023	77.0760	31.3282
4.	Gaussian	Gaussian	1.0514e+04	12.7184	1.2230	102.5373	31.4066
5.	Gaussian	Mean	5.9407e+03	15.1976	3.7023	77.0760	31.3282
6.	Gaussian	BLF-M1	4.6085e+03	16.3004	4.8051	67.8857	29.8277
7.	Gaussian	BLF-M2	4.8989e+03	16.0350	4.5397	69.9923	31.2492

Figure 2:Salt&Pepper Noise with different types of filtering technique:

S.NO	TYPE OF NOISE	FILTER	MSE	PSNR	SNR	RMSE	MD
1.	Salt&Pepper	Median	218.6404	29.5387	18.0434	14.7865	0.0934
2.	Salt&Pepper	Wiener	3.4723e+03	17.5298	6.0345	58.9263	17.9005
3.	Salt&Pepper	Averaging	3.1499e+03	17.9530	6.4577	56.1240	18.0436
4.	Salt&Pepper	Gaussian	7.7312e+03	14.0535	2.5582	87.9274	18.1058
5.	Salt&Pepper	Mean	3.1499e+03	17.9530	6.4577	56.1240	18.0436
6.	Salt&Pepper	BLF-M1	1.2227e+03	22.0628	10.5675	34.9671	13.6364
7.	Salt&Pepper	BLF-M2	2.1971e+03	19.5176	8.0222	46.8730	17.8539

Figure 3:LocalVar Noise with different types of filtering technique:

S.NO	TYPEOF NOISE	FILTER	MSE	PSNR	SNR	RMSE	MD
1.	Localvar	Median	450.1565	26.4024	14.9070	21.2169	3.1409
2.	Localvar	Wiener	882.0083	23.4813	11.9859	29.6986	9.6107
3.	Localvar	Averaging	766.0126	24.0937	12.5983	27.6769	9.5504
4.	Localvar	Gaussian	1.5361e+03	21.0719	9.5765	39.1927	9.5788
5.	Localvar	Mean	766.0126	24.0937	12.5983	27.6769	9.5504
6.	Localvar	BLF-M1	616.4222	25.0372	13.5419	24.8279	9.1872
7.	Localvar	BLF-M2	649.1173	24.8128	13.3174	25.4778	9.5860

Figure 4:Speckle Noise with different types of filtering technique:

S.NO	TYPEOF NOISE	FILTER	MSE	PSNR	SNR	RMSE	MD
1.	Speckle	Median	693.3760	24.5263	13.0310	26.3320	-1.1324
2.	Speckle	Wiener	1.2563e+03	21.9451	10.4498	35.4442	-0.8007
3.	Speckle	Averaging	355.5060	27.4275	15.9322	18.8549	-1.0747
4.	Speckle	Gaussian	983.0325	23.0103	11.5150	31.3533	-1.0746
5.	Speckle	Mean	355.5060	27.4275	15.9322	18.8549	-1.0747
6.	Speckle	BLF-M1	477.6536	26.1449	14.6495	21.8553	-0.8441
7.	Speckle	BLF-M2	324.4163	27.8250	16.3296	18.0116	-0.8006

Figure 5:PoissonNoise with different types of filtering technique:

S.NO	TYPEOF NOISE	FILTER	MSE	PSNR	SNR	RMSE	MD
1.	Poisson	Median	1.8631e+04	10.2336	-1.2617	136.4957	78.2011
2.	Poisson	Wiener	1.8594e+04	10.2423	-1.2531	136.3597	78.0260
3.	Poisson	Averaging	1.8518e+04	10.2600	-1.2353	136.0819	78.8626
4.	Poisson	Gaussian	1.8636e+04	10.2325	-1.2629	136.5141	78.0047
5.	Poisson	Mean	1.8518e+04	10.2600	-1.2353	136.0819	77.8626
6.	Poisson	BLF-M1	1.8566e+04	10.2489	-1.2464	136.2553	77.9871
7.	Poisson	BLF-M2	1.8539e+04	10.2551	-1.2403	136.1592	77.8335

Theresultsshowsthatthe Salt and Peppernoise affected imageiseffectivelyde-noisedwithMedianfilterso wegetlow MSEandhigh PSNRvaluecompared to otherfiltersbut, when compared to Salt and pepper noise,Speckle noise and Gaussian filtered image showshighMSEvalues so it is not suitable for de-noising MRI medical images.

VI.CONCLUSION

Reducing the noise in an image using filtering techniques will improve the results of an image - MRI images when captured usually have all types of noises. To remove these noises, few filtering techniques like wiener filter, median filter, mean filter, bilateral filter are used. In this paper various filtering algorithms are developed and implemented on MRI images. Theright choice of filterfor de-noising the MRI images depends on the rightfiltering technique we choose. Among various filters, median and mean filter gives better result in MRI brain images. The further work on this modified median and mean filter technique may let us to achieve 30-40% increase PSNR and 10- 15% reduce MSE value.

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