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De-Noising of MR Brain Tumor Images by using Noise Filtering Techniques

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***Abstract*—** Image processing is a powerful tool for increasing the reliability and reproducibility of disease diagnostics. Magnetic Resonance Imaging (MRI) is one of the best technologies currently being used for diagnosing brain tumor. Brain tumor is diagnosed at advanced stages with the help of the MRI image. Preprocessing is an important process to extract suspicious region from complex medical images. Automatic detection of brain tumor through MRI can provide the valuable outlook and accuracy of earlier brain tumor detection. In this paper an intelligent system is designed to diagnose brain tumor through MRI using image preprocessing filters such as Wiener Filter, Lee Filter, Gabor Filter, Median filter and Mean Filter. This paper gives the analysis of selection of proper filter according to the required parameters for best result and at the same time their comparative study enhances the selection of proper filter as per requirement.

Keywords— *Wiener Filter; Lee Filter; Gabor Filter; Median filter; Mean Filter Turnover.*

1. Introduction

Tumour is defined as the abnormal growth of the tissues. Brain tumor is an abnormal mass of tissue in which cells grow and multiply uncontrollably, seemingly unchecked by the mechanisms that control normal cells. Brain tumors can be primary or metastatic, and either malignant or benign. A metastatic brain tumor is a cancer that has spread from elsewhere in the body to the brain. Epilepsy is a brain disorder in which clusters of nerve cells, or neurons, in the brain sometimes signal abnormally. Neurons normally generate electrochemical impulses that act on other neurons, glands, and muscles to produce human thoughts, feelings, and actions. In epilepsy, the normal pattern of neuronal activity becomes disturbed, causing strange sensations, emotions, and behavior or sometimes convulsions, muscle spasms, and loss of consciousness [1].

Pre-processing of MRI images is the primary step in image analysis which perform image enhancement and noise reduction techniques which are used to enhance the image quality. In this paper, different image preprocessing methods are compared based on their ability to remove noise such as Wiener Filter, Lee Filter, Gabor Filter, Median filter and Mean Filter.

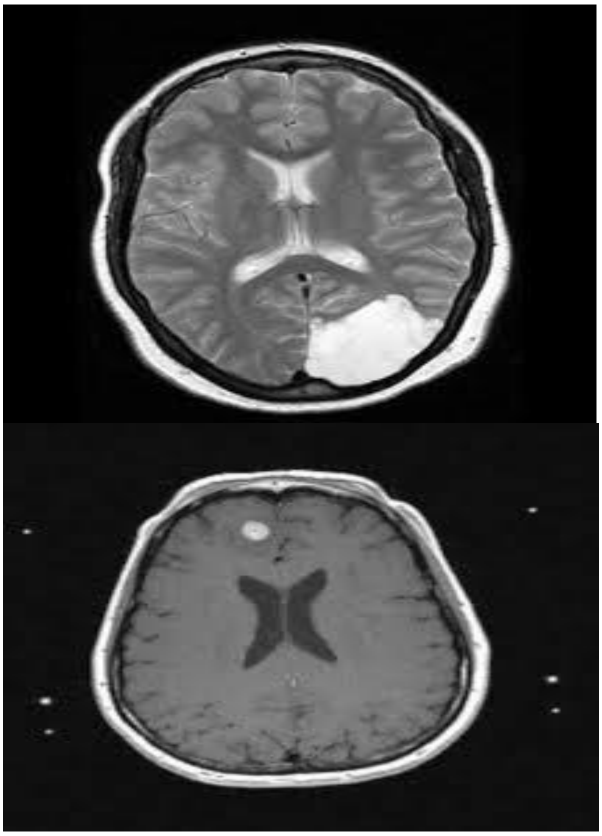

Fig.1: MRI Brain Image with Tumor

2. Magnetic Resonance Imaging

Magnetic Resonance Imaging (MRI) is an advanced medical imaging technique used to produce high quality images of the parts contained in the human body MRI imaging is often used when treating brain tumors, ankle, and foot. From these high-resolution images, we can derive detailed anatomical information to examine human brain development and discover abnormalities.

Magnetic resonance imaging (MRI) is a medical imaging procedure that uses strong magnetic fields and radio waves to produce cross-sectional images of organs and internal structures in the body. Because the signal detected by an MRI machine varies depending on the water content and local magnetic properties of a particular area of the body, different tissues or substances can be distinguished from one another in the study image. MRI consists of T1 weighted, T2 weighted and PD (proton density) weighted images and are processed by a system which integrates fuzzy based technique with multispectral analysis [2].

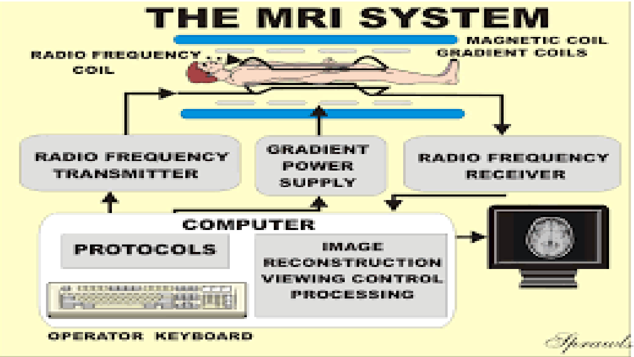

Fig 2: MRI System

In most MRI devices, an electric current is passed through coiled wires to create a temporary magnetic field around a patient's body. Radio waves are sent from and received by a transmitter/receiver in the machine, and these signals are used to produce digital images of the area of interest [2].

3. Preprocessing

Pre-processing mainly involves those operations that are analysis and extraction of the desired information and normally geometric corrections of the original image. These improvements include correcting the data for irregularities and unwanted atmospheric noise, removal of non-brain element image and converting the data so they correctly reflected in the original image. There are several filtering technology's which can improve the MRI image quality but there are several advantage and disadvantage which describe very shortly individually [3]. Median Filter, Low pass Filter, Gradient Based Method, Prewitt edge-finding filter, Nonlinear Filter, V-filter, and other filter with contrast Enhanced filter are shortly describe below.

3.1 Wiener Filter

In this approach, consider the image B, as an input image (A) plus Poisson noise (g).

$$B = A + g$$

Where B = Resultant Image, A= Input Image and g = Poisson Noise. Wiener Filter estimates the local mean and variance around each pixel.

$$\mu = 1/NM \sum_{n_1 n_2 \epsilon \eta} a(n1, n2)$$

and

$$\sigma^2 = 1/NM \sum_{n_1 n_2 \epsilon \eta} a^2(n1, n2) - \mu^2$$

Where η the N-by-M local neighborhood of each pixel is in the image A. wiener then creates a pixel wise. Wiener filter using these estimates,

$$b(n1n2) = \mu + \sigma^2 - v^2/\sigma^2(a(n1n2) - \mu)$$

Where, v^2 is the noise variance. If the noise variance is not given, wiener uses the average of all the local estimated variances. This Filtering is also called Minimum Mean Square variances. This Filtering is also called Minimum Mean Square Error (MMSE) or Least Square (LS) Filtering [4].

Wiener filter performs smoothing of the image based on the computation of local image variance. When the local variance of the image is large the smoothing is little on the other hand if the variance is small, smoothing will be better. Wiener filter can be used as decorrelator of speckle, which makes its distribution more in reflectivity. If reflectivity is reasonably assumed to be corrupted by multiplicative noise then an adaptive ML estimation approach is utilized to eliminate such noise [5].

3.2 Lee Filter

The multiplicative lee filter [6] approximates the below equation

$$I(x,y) = R(x,y)n(x,y)$$

Where, I(x,y) is the observed image, (x,y) are the spatial coordinates, R(x,y) is the signal reflectivity and n(x,y) represents the speckle noise, with linear model to obtain the signal estimate R^. The formulation of [4] is as follows

$$R\hat{} = I(x,y)W(x,y) + I(x,y)\{1 - W(x,y)\}$$

Where W(x,y) is the weighing function. This filter is incapable of removing high frequency noise and also it cannot remove noise in high and low variance regions. An improved version of lee filter known as enhanced lee filter (Enh Lee) which eliminates the demerits of lee filter mentioned above [7].

Lopes et al. [8] expands the Lee et. Al approaches by adapting to local heterogeneity, based on CI(x,y) which represents the effective descriptor of textural information and image homogeneity, the image is split into three regions of different filtering ,using thresholds and one of the thresholds determines how much of the image is to remain unfiltered.

3.3 Gabor Filter

In image processing, a Gabor filter, is a linear filter used for image denoising. Its impulse response is defined by a harmonic function multiplied by a Gaussian function. Because of the multiplication-convolution property

(Convolution theorem), the Fourier transform of a Gabor filter's impulse response is the convolution of the Fourier transform of the harmonic function and the Fourier transform of the Gaussian function. The filter has a real and an imaginary component representing orthogonal directions. The two components may be formed into a complex number or used individually [9]. Complex

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma) = \exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right)\exp\left(i\left(2\pi\frac{x'}{\lambda}+\psi\right)\right)$$

Real

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma) = \exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right)\cos\left(2\pi\frac{x'}{\lambda}+\psi\right)$$

Where

$$x' = x\cos\theta + y\sin\theta$$

and

$$y' = -x\sin\theta + y\cos\theta$$

In this equation, λ represents the wavelength of the sinusoidal factor, θ represents the orientation of the normal to the parallel stripes of a Gabor function, ψ is the phase offset, σ is the sigma of the Gaussian envelope and γ is the spatial aspect ratio, and specifies the ellipticity of the support of the Gabor function [9].

4. Median Filter

Median filter, the most prominently used impulse noise removing filter, provides better removal of impulse noise from corrupted images by replacing the individual pixels of the image as the name suggests by the median value of the gray level The median of a set of values is such that half of its values in the set are below the median value and half of them are above it and so is the most acceptable value than any other image statistics value for replacing the impulse corrupted pixel of a noisy image for if there is an impulse in the set chosen to determine the median it will strictly lie at the ends of the set and the chance of identifying an impulse as a median to replace the image pixel is very less.

A commonly used non-linear operator is the median, a special type of low-pass filter. The best known order-statistics filter is the median filter, which replaces the value of a pixel by the median of the gray levels in the neighborhood of that pixel

$$\hat{f}(x,y) = \underset{(s,t)\in S_{xy}}{\text{median}}\ \{g(s,t)\}$$

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 [10].

5. Mean Filter

One of the simplest linear filters is implemented by a local averaging operation where the value of each pixel is replaced by the average of all the values in the local neighborhood. This is the least satisfactory method of speckle noise reduction as it results in loss of detail and resolution. However, it can be used for applications where resolution is not the first concern. Even though these filters offer simplicity of implementation, they fail to preserve many useful details and to distinguish boundaries between the areas with low difference in gray level. This filter is more suitable to reduce artificial noise like salt and pepper noise and Gaussian noise. This filter does not have the capability of preserving edges. This filter performs poorly when it comes to real MRI image [11].

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

Let Sxv represent the set of coordinates in a rectangular sub image window of size m X n, centered at point (x, y).The arithmetic mean filtering process computes the average value of the corrupted image g(x, y) in the area defined by Sxy. The value of the restored image at any point (x, y) is simply the arithmetic mean computed using the pixels in the region defined by S [12].

6. Literature Review

Various wavelet filter based denoising methods are studied according to different thresholding values and applied to ultrasound images [13].Joshi etal. Modeled the fused multispectral (MS) image using a low spatial resolution MS images as the aliased and corresponding noisy versions as high spatial resolution. The fused image is obtained for each of the MS bands by estimating the high spatial resolution and then modeling as separate inhomogeneous Gaussian Markov random fields (IGMRF) and a maximum a posteriori (MAP) estimation [14].

An adaptive weighted averaging filter is given to indicate the spatial influence of the center pixel. Panas et al. Proposed the Adaptive Fuzzy Clustering/Segmentation (AFCS).In AFCS, then on stationary nature of the taken the image in account using modifying the prototype vectors as function of sample location in the image. A multimodal is utilized for varies of estimating the spatially prototype vectors for different window sizes. The results provide segmentation having lower entropy [15].Mohamed et al. described the application of fuzzy set theory in medical imaging.

Priyanka. Balwinder Singh proposed *Median Filter technique* for de-noising the salt and pepper noise and Poisson noise from the images. In a median filter, a window slides along the image and the median intensity value of the pixels within the window becomes the output intensity value of the pixel being processed. Median filter preserves edges in an image while reducing random noise. Each pixel is set to median of the pixel values in the neighborhood of the corresponding input pixels. This filter is used to remove these noises and bounding box method is implemented to identify the location of the tumor [16].

Order statistics filters present a simple and efficient technique to remove noise from the medical images which combines both median filtering and mean filtering to determine the pixel value in the noise less image. This method is used to remove the Rician noise which affects the MRI images [17].This method performs much better than the other filtering methods which was developed by M. N. Nobi and M. A. Yousuf.

C.Ramalakshmi and A.Jaya Chandran developed *anisotropic filter* to remove the background noise and thus preserving the edge points in the image. This technique applies a concurrent filtering and contrast stitching. Diffusion constant related to the noise gradient and smoothing the background noise by filtering a proper threshold value is chosen [18].

De-noising using *weighted median filter* is applied to remove high frequency components and it can remove salt and pepper noise from MRI without disturbing of the edges. It is applied for each pixel of a 3*3,5*5,7*7,9*9.11*11 window of neighborhood pixels are extracted and analyzed the mean gray value of foreground mean value of background and contrast value has been employed by J.Jaya. K.Thanushkodi, M.Karnan in 2009 [19].

Table 1: Results

S. No	Name of Filter	Advantage	Disadvantage	Accuracy
1	Wiener Filter	Decorelation makes its distribution more independent	Image is partially enhanced	94.3%
2	Lee Filter	Preserve texture and high frequency information	Poor quality of images in removing high frequency noise	93%
3	Gabor Filter	Provides good edges txt extraction	Very sensitive to scale, orientation and frequency of texture	96%
4	Median filter	Preserves edges in images	Cannot distinguish noisy detail from non noisy detail	92%
5	Mean Filter	Reduces noise within the target area	Cannot preserves edges in images and not suitable for speckle noise	89%

7. Analysis of Filters

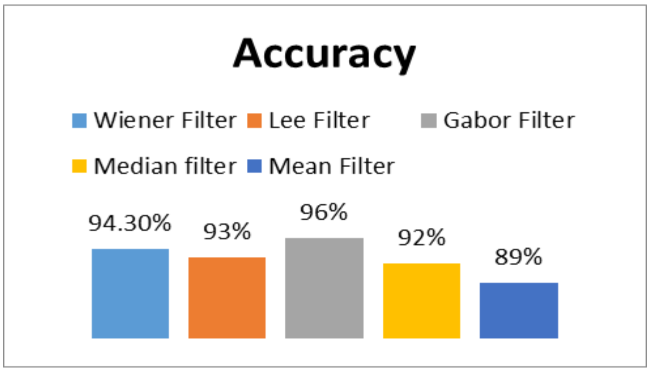

Fig.3: Accuracy graph for noise reduction filtering techniques

From the existing system, Most of the research showed a large difference between each filter's sensitivity and specificity results. Filtering techniques like Wiener Filter, Lee Filter, Gabor Filter, Median filter and Mean Filter elucidated in this table. Table V and Fig 3 illustrates the accuracy results for noise reduction for above mentioned methods**.**

8. Conclusion

Medical Image Processing is the fast growing and challenging field now a day. Medical Image techniques are used for Medical diagnosis. Processing of MRI images is the part of this field. Brain tumor is a serious life threatening disease. Noise degrades the visual evaluation in MR imaging. Speckle noise is the most common form of noise present in MR images. This paper describes different image filtering techniques for denoising MRI Brain tumor image. Five image filters such as Wiener Filter, Lee Filter, Gabor Filter, Median filter and Mean Filter were discussed in MRI images to improve the performance of further image processing steps.

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