Tumour Detection Using Magnetic Resonance Images: A Survey

[1]Amit Sharma, [2]Priyanka
[1]M.Tech. Scholar, ECE Dept. DCRUST Murthal, Sonipat, Haryana, India
[2]Associate Professor, ECE Dept. DCRUST Murthal, Sonipat, Haryana, India

Abstract - The process of detecting brain tumour incorporates processes such as pre-processing of the image, image segmentation to detect the region of interest and feature extraction from the image etc. The process of pre-processing the MRI images incorporates detection and removal of noise present in the image and the image enhancement. There are different types of noises which can affect the image. In this way we present introduction of different types of noises in MRI images and methods to remove these noises and to enhance image.

Keywords - *Noises in MRI, Noise Removal methods, Image enhancement.*

I. INTRODUCTION

In medical image processing it is important to obtain quality image for facilitating the image classification accuracy. As the poor image quality is an obstacle for feature extraction from the images. Magnetic resonance imaging (MRI) is an imaging technique which is used for assessing the pathological or physiological alterations of living tissues by visualizing the internal structure of the tissues and organs in the body. Other imaging technologies are also there like X-ray, Computed Tomography. But MRI differs from these modalities in such a manner that it can characterise and discriminate among tissues using their biochemical and physical properties. It can produce image, without moving the patient and it does not cause the harmful radiations to the patient.[1] MRI is considered now as an important tool for surgeons. It delivers high quality images of the inside of the human body. One should be careful when dealing with sensitive organs like the brain. A brain tumour is an intracranial mass created by abnormal and uncontrolled cell division. Tumours can destroy brain cells or damage them indirectly by causing inflammation, compressing other parts of the brain, including cerebral edema or by exerting internal pressure as they grow.[2]

In clinical diagnosis, the visual quality of magnetic resonance images plays an important role. But during acquisition or transmission these images are corrupted with noises, which hinder the medical diagnosis based on these images.

Noise means, the pixels in the image show different intensity values instead of true pixel values. The common types of noise that arises in the images are a) Impulse noise, b) Additive noise c) Multiplicative noise. Different noises have their own characteristics which make them distinguishable from others.

Noise in MR images obeys a Rician distribution. Unlike additive Gaussian noise, Rician noise is signal-dependent and consequently separating signal from noise is a difficult task.[4] So much of the works has been done on the restoration of images which are corrupted by noise. Several filters are used to remove noise from an image by making a change in the pixels intensity. By taking neighbouring pixels into consideration, these noisy pixels can be filtered out. Unfortunately, the pixels whose intensity is changed can also represent original fine details of the image, which can also be lost in the noise removal process. There is no unique technique for noise removing from affected image. Different processes are used depending on the noise model. For example the averaging filtering technique can successfully remove noise from the distorted image but in this case the filtered image suffers the blurring effect.

Hence noising removal of the image is necessary and the foremost step in the image analysis process. Image denoising is still challenging because removal of noise from the noisy image causes other artefacts and image blurring. Different algorithms are used for denoising which depends on noise model and modelling of noise depends on many factors like data capturing instrument, transmission media, and quantization of image.

Different noise removal and image enhancement techniques are used to improve the clarity of an image for better visualization, diagnosis and therapeutic planning. The main function of image enhancement is to carry out the hidden part in an image or to enhance the low contrast image. The quality of the image gets better by contrast manipulation. A very well-liked performance for contrast enhancement is Histogram Equalization (HE). The most part of techniques is used, due to simplicity and moderately better performance on images [5].

II. NOISES IN MRI

Noise modelling in images is affected by capturing instrument, data transmission media, image quantization and discrete source of radiation. Gaussian noise (random additive) is observed in natural images, where as rician noise affects magnetic resonance image (MRI). The characteristics of noise depend on its source, as does the operator which reduces its effects.

In the digital images like MRI, noises have low and high frequency components. As compare with low frequency components removing high frequency components is very easy and low frequency noise cannot be distinguished easily. Noise in MRI mostly obeys Rician distribution. The term rician noise is used to denote the error between underlying image intensities and the observed data. Its mean depends on the local intensity in the image. Rician noise is signal dependent and problematic in high resolution, low signal to noise ratio not only causes random fluctuations but also introduces as signal dependent bias to the data that reduces image contrast. As bias field signal is low frequency signal which corrupts MRI images because of inhomogenities in the magnetic field of MRI machines; the image gets blurred and the high frequency components gets reduced such as edges and contours of the images. Because of this tissues have different grey level distribution across the image. Image processing algorithms like segmentation, classification or texture analysis uses the grey level values of that image pixel; which will not give satisfactory results. The pre-processing is required for correction of these corrupted bias field signals before submitting corrupted MRI to such algorithms.[16] Rician noise affects the image in both quantitative and qualitative manner and thus it hinders image analysis, interpretation and feature detection. So denoising method is required which removes this noise. Denoising is nothing but the removing of noise from image while retaining the original quality of the image. Preserving the edges and the fine details of the image while suppressing noise; is a great challenge in noise removal. It still remains challenge for researchers as noise removal introduces artefacts and causes blurring of the images [1]. So, it is necessary to develop an efficient denoising technique to avoid such knowledge corruption.[1]

A. Rician noise

MR images are corrupted by Rician noise, which arises from complex Gaussian noise in the original frequency domain measurements. The probability density function for the Recian corrupted image intensity x is given by:

$p(x)=(x/\sigma^2)\exp(-(x^2+A^2)/2\sigma^2)I_0(xA/\sigma^2)$

where A is the underlying true intensity, σ is the standard deviation of the noise, and I_0 is the modified zeroth order Bessel function of the first kind.[4]

B. Impulse Noise (Salt and Pepper Noise)

This is also named as impulsive noise or spike noise or independent noise or random noise. Black and white dots appear in the image as a result of this noise and hence called as salt and pepper noise. This noise arises in the image because of sharp and sudden changes of image signal. Dust particles in the image acquisition source or over heated faulty components can cause this type of noise.[6,7]

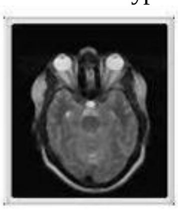

Fig.1: Image after salt and pepper noise

It presents itself as sparsely occurring white and black pixels. An effective noise reduction algorithm for this type of noise involves the usage of a median filter. Minimum filtering, maximum filtering, mean filtering, rank order filtering are the some other filters which reduces lesser amount of noise compare to median filter. Without significantly reducing the sharpness of the image, salt and pepper noise can be reduced.

C. Gaussian noise

The term normal noise model is the synonym of Gaussian noise. This noise model is additive and follow Gaussian distribution. It means each pixel in the noisy image is the sum of the true pixel value and a random Gaussian distributed noise value. The noise is independent of intensity of pixel value at each point. The PDF of Gaussian random variable is given by:

$P(x) = 1/ (\sigma\sqrt{2\pi})*e^{(x-\mu)2}/2\sigma^2$

Where: *P(x)* is the Gaussian distribution noise in image; μ and σ is the mean and standard deviation respectively.
Gaussian noise removal algorithms should smooth the distinct parts of the image. In image processing Gaussian noise can be reduced using spatial filter. A special case of Gaussian noise is white Gaussian noise, in which the values are statistically independent which describes the correlation of noise. Gaussian noise is used as an additive white noise to produce additive white Gaussian noise.[6,7]

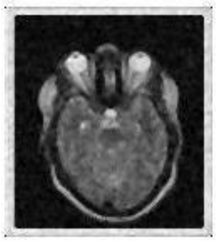

Fig.2: Image after Gaussian noise

D. Noise Removal Methods

Noise reduction is the process of removing noise from a signal. Medical images are corrupted with different kinds of noise while image acquisition.[4]

(i) Linear smoothing filter

The Mean filter is a linear filter which uses a mask over each pixel in the signal. Each of the components of the pixels which fall under the mask are averaged together to form a single pixel.

$f(x,y) = (1/mn)\ \Sigma_{(s,t)\in S_{xy}}\ g(s,t)$

where *f* is the restored image and *g* is the corrupted image.
Fig (a) shows the original MRI brain image. Fig (b) shows the image after mean filter

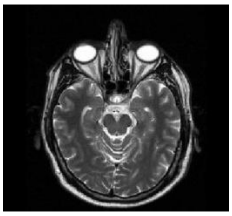

Fig.3 (a): Original image

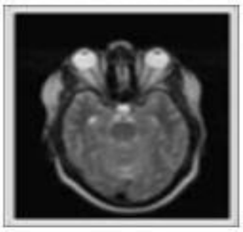

Fig.3 (b): image after mean filter

(ii) Median filter

The median filter is also the simpler technique and it removes the speckle noise from an image and also removes pulse or spike noise. The Median Filter is performed by taking the magnitude of all of the vectors within a mask and sorting the magnitudes. The pixel with the median magnitude is then used to replace the pixel studied. The Operation of median filter can be expressed as:

$$f(x,y) = \text{median}_{(s,t)\in Sxy}\{g(s,t)\}$$

Where Sxy represents the set of coordinates in a rectangular sub image window, centred at point (x,y), and median represents the median value of the window.
Fig (a) shows the original image of MRI brain image. Fig (b) shows the output image after median filter.

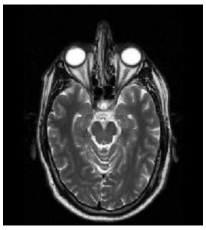

Fig.4 (a): original image

Fig.4 (b): image after median filter

(iii) Midpoint filter

In the midpoint filter, value of each pixel is replaced with the average of highest pixel and the lowest pixel (with respect to intensity) values in a surrounding region. The operation of this filter can be expressed as:

$$f(x,y) = (½)[\max_{(s,t)\in Sxy}\{g(s,t)\}+\min_{(s,t)\in Sxy}\{g(s,t)\}]$$

Where Sxy represents the set of coordinates in a rectangular sub image window, centred at point (x,y), also max and min represents the maximum and minimum value of the window respectively.

(iv) Wiener Filter

Wiener filter carry out an optimal between inverse filtering and noise smoothing. It removes additive noise and deblurring concurrently. This proves to be optimal in reducing the overall Mean Square Error (MSE). The operation involves two parts. One is inverse filtering and the other is noise smoothing. Wiener filters belong to a kind of optimum linear filters with the noisy data as input which involves the calculation of difference between the desired output sequences from the actual output. The performance can be measured using Minimum Mean-Square Error.
Fig (a) shows the original image of MRI brain image. Fig (b) shows the image after wiener filter.

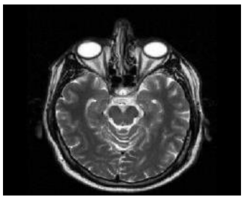

Fig.5 (a): original image

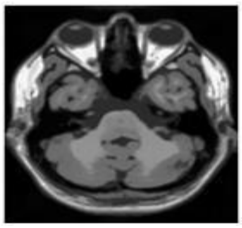

Fig.5 (b): Image after wiener filter

(v) Adaptive Filter

Wiener2 is a 2-D adaptive noise removal filter. The wiwner2 function applies a wiener filter which is a type of linear filter to an image adaptively, tailoring itself to local image variance. Where the variance is large, wiener2 performs little smoothing. Where the variance is small, wiener2 performs more smoothing. This approach often produces better result than linear filtering. The adaptive filter is more selective than a comparable linear filter, preserving edges and other high frequency parts of an image. In addition, there are no design tasks; the wiener2 function handles all preliminary computations, and implements the filter for preliminary computations, and implements the filter for an input image. Best suitable to remove Gaussian noise.

Fig (a) shows the original image of MRI brain image. Fig

(b) shows the image after adaptive filter

Fig.6 (a): original image

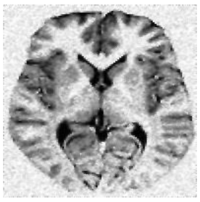

Fig.6 (b): image after adaptive filter

E. Parameters used for Analyzing the De-noised Image

Different kinds of statistical measurement can be used to analysis the performance of the output image. The root mean square error (RMSE), signal-to-noise ratio (SNR), and peak signal-to-noise ratio (PSNR) are used to evaluate the enhancement performance.

Signal-to-noise ratio (SNR) is a measure to quantify how much a signal has been corrupted by noise. The root mean square error (RMSE) is used to find the total amount of difference between two images. It indicates the root of average difference of the pixels throughout the image. The peak signal to noise ratio (PSNR) is the ratio between the maximum possible power of a signal and the power of corrupted noise that affects the fidelity of its representation. A higher PSNR would normally indicate that the reconstruction is of higher quality.

A. Mean Square Error (MSE)

This is one of the error criteria used in this work.MSE is the squared difference between the original and the denoised image. This gives us the difference between original image and the denoised image. Its given by:

$$MSE = \frac{1}{MN} \sum_{m=0}^{N-1} \sum_{n=0}^{M-1} (y(m,n) - y'(m,n))^2$$

Where y(m,n) is the original image and y`(m,n) is denoised image with relation to image dimension(m,n).

B. Signal to Noise Ratio (SNR)

SNR is very useful way of comparing the relative amount of signal and noise .signal to noise ratio estimates the quality of a reconstructed image compared with an original image.High measures will have very little amount of noise and opposite is true for low ratios.

$$SNR = \frac{\sigma s}{\sigma n}$$

Where σs and σn are the variance of the original image and recorded image. This gives us the difference between original image and the denoised image.

C. Peak Signal to Noise Ratio (PSNR)

It is the ratio between maximum possible power of a signal and the power of corrupting noise that affects the quality and reliability of its representation. PSNR is calculated as

$$PSNR = 10Log_{10}\left(\frac{MAX^2}{MSE}\right)$$

Where MSE is mean square error and MAX is the maximum pixel value of image.[1]

D. Comparison of different Filtering Methods

Filtering Method	SNR(db)	PSNR(db)	RMSE
Smoothing Filter	3.81	43.43	441.58
Median Filter	3.71	43.64	431.33
Midpoint Filter	3.60	42.08	515.75

E. Image Enhancement

Digital Image Processing (DIP) engages the modification of digital data for improving the image qualities with the aid of computer. The processing helps in maximizing clearness, sharpness and details of features of attention towards Information extraction and further analysis. In below diagram “Fig.7” shows the MRI brain image.

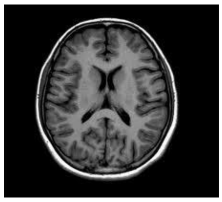

Fig.7: MRI brain image

Enhancement is the alteration of an image to adjust impact on the viewer. Generally enhancement alters the original digital values to bring out specific features of an image, and Highlight the certain characteristics of an image. The processed image is more suitable than the original image for a particular application. In the below diagram “Fig.2” shows the Histogram Equalization.

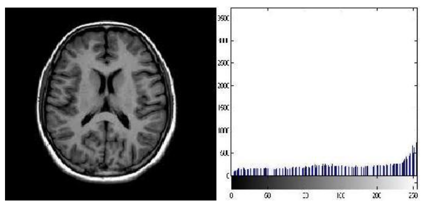

Fig.8 Histogram equalization for MRI brain image

The classical contrast enhancement is Histogram Equalization (HE), which has good performance for ordinary images, such as human portraits or natural images Transformation or mapping of each pixel of input image into corresponding pixel of processed output image is called Histogram Equalization.[5]

III. CONCLUSION

In this paper image filtering algorithms are studied for MRI images to remove the different types of noise that are either present in the image during acquisition or injected in to the image during transmission. MRI images when captured may have different type of noise. In this work, different image filtering methods are compared for the noisy images. The performances of the filters are measured using the Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE). And image enhancement process for clearer images has been studied.

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Amit Sharma
M.tech. Scholar, ECE Deptt.
DCRUST Murthal Sonipat; B.Tech. from VCE Rohtak

Dr. Priyanka
Associate Professor, ECE Department, DCRUST Murthal Sonipat