An Efficient Technique to Detect Brain Tumour using Magnetic Resonance Images

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Abstract— *MR Images suffers from the noises which are having different characteristics. It is always desired to have a noise free image for diagnosis. A technique that can detect the type of noise by which a particular pixel is affected is the necessity to get a noise free image. Knowing the type of noise, a filter can be used which is best to remove such kind of noise. After getting a filtered image it is required to get a clear view of the lesion from MRI image for further processing. Image segmentation using an edge detection technique is used which gives a clear view of boundaries of the lesson/tumour.*

Keywords— Noise, Median Filter, Wiener Filter, MSE, PSNR

I. INTRODUCTION

Magnetic Resonance Image (MRI) gets affected by various kind of noises and the sources of noise may be the electronic items present in the system like the amplifier etc. and sometimes the patient itself causes noise in MRI images. Body movement of the patient and the molecular movement in the body or the body temperature may cause noise. The various kind of noise in MR images may be Impulse noise, Thermal noise, Random stochastic type white Gaussian noise or a mixture of these. This noise affects the image and can change the information content of pixels of the image and even the noise may change the contrast level of the image. In diagnosis process visual quality of the image should be very good. The image removed of all noise is also required for further processing on the image like segmentation or feature extraction etc.[1][7]

As the noises in MRI images have variable characteristics hence the filter methods also have variable characteristics to remove all such kind of noises from MRI images. After filtration process a smooth image is obtained and this image is then further processed by an edge detection technique. The image after such a technique will have clear boundary separation for the tumour from other part of the organ. There are various techniques for edge detection purpose; all have different nature and variable degree of segmentation.[17]

II. TYPE OF NOISE AND NOISE REMOVAL METHODS

The noise removal techniques use different aspects of the image such as for some techniques mean value of a group of the pixels is considered and for some other median, for some technique the variance may be taken as referring parameter for noise removing and for some other standard deviation. The noises in MRI images are random stochastic type noise which affects the image pixel value in complex plane i.e. its real and imaginary values both. Usually it is the white Gaussian noise which is present in the MR images but when magnitude MR image is considered the noise follows the Rician probability distribution function (PDF), hence the noise is named as Rician noise. The Rician noise is signal dependent and is difficult to remove from image.[10][12] The various noise found in MR Images are described as follows:

Impulse (Salt & Pepper) Noise corrupts some pixels of the image and that is why it is also called as Data drop noise. The pixels value is replaced with the maximum or minimum pixel value which are 255 and 0 in case of 8 bits data. Black and white dots appear in the image as a result of this noise and hence it is also known as salt and pepper noise.

The Gaussian noise arises in digital images because of the natural sources such as thermal vibrations of the atoms and discrete nature of radiations in the warm object (Patient body temperature). Gaussian noise model follows the additive nature i.e. in the noisy image each pixel is the sum of original image pixel value and the noise value. The noise is independent of the pixel value and follows the Gaussian probability distribution function which is given as:

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

Where $p(x)$ is the Gaussian distribution of noise in image, μ and σ are the mean and standard deviation respectively; x is the gray value of the image pixels.

White Gaussian noise is a special type of 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. The autocorrelation of white noise is zero. In additive white Gaussian noise a constant random value is added to each pixel of the image which is distributed as the Gaussian distribution. The white Gaussian noise has stochastic random nature.

In magnitude MR Images the noise present follows the Rician distribution and thus called the Rician noise. Gaussian noise present in MR images disturbs the values of both (real and imaginary) parts of each pixel in the image. Magnitude image of the noisy MR image has noise which follows Rician probability distribution function. In images with low SNR this noise creates a big problem and reduces the image contrast as well. The Rician PDF is given by the equation [3]:

$$\mathrm{p(x)} = \frac{x}{\sigma^2} * \mathrm{e}^{-\left(\frac{x^2+A^2}{\sigma^2}\right)} * I_0\left(\frac{A_x}{\sigma^2}\right)$$

Where σ is the standard deviation, x is the pixel value of the magnitude image and I_0 is the zeroth order Bessel function and A is the true image intensity without noise and is given by: $A=A_R+A_I$, where A_R & A_I are real and imaginary data respectively.

When A→0 noise is found to end with Rayliegh distribution and with high values of A it approaches to Gaussian distribution. Rician noise is caused due to Gaussian noise in the frequency domain of the original image.[4,8,9,13 and 15]

A. Noise Removal Methods

Filters used for noise removal from noisy MR Images are described as under:

1) Mean Filter

The Mean Filter computes the average value of a predefined area of the noisy image and the central pixel value is replaced with the average value of neighbouring pixels. Hence this is also called averaging Filter. The average can be computed as:

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

Where $f(x,y)$ is the restored image using averaging filter and $g(x,y)$ is the noisy image and S_{xy} represents the set of coordinates in a rectangular sub image window, cantered at point(x,y).

2) Median Filter

The Median filter is a nonlinear filter and preserves edges and sharpness of the image as compared to the mean filter and hence Median filter is more advantageous over the Mean filter. It does a great job in removing impulse or Salt & Pepper noise. In Median filtering technique each pixel of the image is replaced by the median computed from a neighbourhood of the pixel. This neighbourhood window is of square size. This method does not cause much loss to the boundary information as compared to the Mean filter. It is very good in removing the Impulse noise. This filter can be used repetitively more number of times as it causes less loss to the boundary and sharpness of the image.

Median filter does a smoothing of the image pixels by removing noise, but it smoothes only those pixels whose value differs more from others in its surroundings and does not change other pixel values.

Using Median filter reverse filtering can also be done for restoration of the pixels without having Impulse noise. The pixels which are not having Salt & Pepper noise i.e. not having a maximum (255) or minimum (0) intensity levels can be retained as it is as in the original image. The pixels which are having Salt & Pepper noise are replaced with the median value of a neighbourhood window. In this way Median filter becomes a great tool for removal of Impulse noise without causing artefacts and blurred effect.[3,4,5 and 15]

3) Wiener Filter

The Wiener filter is a filter used to remove noise from a noisy image and also deblurring the image using a stochastic approach. It basically minimizes the mean square error between noisy image and the original MR image as lower as possible. Main purpose of this statistical approach is to diminish the noise present in a signal by comparing it with an estimation of the desired noiseless signal. Wiener filters are characterized by an assumption that signal and (additive) noise are stationary linear random processes and their spectral characteristics are calculated. 'wiener2' function in MATLAB is a 2-D adaptive noise removal filter function. The 'wiener2' 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 results 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 an input image. Wiener Filter is best suitable to remove Gaussian noise.[4,6,7,9,10 and 11]

III. EDGE DETECTION TECHNIQUE

Edge detection is an image processing technique for finding the boundaries of objects within images. It works by finding discontinuities in intensity level of pixels of the image. Edge detection is used for image segmentation and data extraction. Common edge detection algorithms are Canny, Sobel, Prewitt, Roberts etc. Measuring the relative brightness of pixels in a neighbourhood is mathematically analogous to calculate the derivative of brightness. Brightness values are discrete, not continuous, so we approximate the derivative function. Different edge detection methods use different discrete approximations of the derivative function.

A. Canny Edge Detection

The canny edge detection algorithm is also known as optimal edge detector. Canny edge detection algorithm makes sure that all the edges be detected including the weak edges also. For this purpose this algorithm first smoothes the image to eliminate noise and then finds the image gradient. It finds edges by looking for local maxima of the gradient of the Image. The edge detection algorithm calculates the gradient using the derivative of a Gaussian filter. This method uses two thresholds to detect strong and weak edges, including weak edges in the output if they are connected to strong edges. By using two thresholds, the canny method is less likely than the other methods to be fooled by noise, and more likely to detect true weak edges.[2,3,4]

IV. PROPOSED WORK

For detection of a brain tumour using Magnetic Resonance Image of brain first step is image acquisition. Image is acquired by the MRI machines. The noise then adds to the image in image transmission or storage process. Hence the second step is to remove the noise from MRI image. And finally the third step is to detect the tumour boundary using edge detection technique to have a clear view of the tumour.

A hybrid filter which is a combination of two filters is modelled which removes the noise and causes lesser blurring effects and artefacts to the image. This filter works on each pixel of MR image and finds the noise and performs filtration on that pixel while preserving the information. If any pixel has intensity value equal to 0 or 255 i.e. minimum or the maximum value which means that pixel is having Impulse (Salt & Pepper) noise. This noise can be effectively removed by using Median Filter. Median filter is not well suitable to apply to the complete image because it will cause blurring effect and artefacts to the image. The remaining pixels of the MR image have additive white Gaussian noise. Wiener filter is not that much good for removing Impulse noise as the median filter, but Wiener filter is best suitable to remove such type of white Gaussian noise. An algorithm is used which will replace the pixel value of those pixels which are having Impulse noise; by the Median filter(3X3) output for that pixel i.e. by the Median of neighbourhood and it will replace other pixel values with the output of Wiener filter(5X5). In this way blurring effect caused by filters and artefacts got reduced up to a large extent. The resultant image thus produced has minimum Mean Square Error (MSE), and Minimum Root Mean Square Error (RMSE), and maximum Peak Signal to Noise Ratio (PSNR).

$$\mathrm{MSE} = \frac{1}{mn}\sum_{k=0}^{m-1}\sum_{l=0}^{n-1}(y(k,l) - y'(k,l))^2$$

$$\mathrm{RMSE} = \sqrt{\mathrm{MSE}}$$

Where $y(k,l)$ is the original image and $y'(k,l)$ is denoised image with relation to image dimension (m,n).

$$\mathrm{PSNR} = 10\log_{10}\frac{\mathrm{MAX}^2}{\mathrm{MSE}}$$

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

Finally a noiseless image is obtained which is used for edge detection by using canny edge detection technique.

A. *Flowchart*

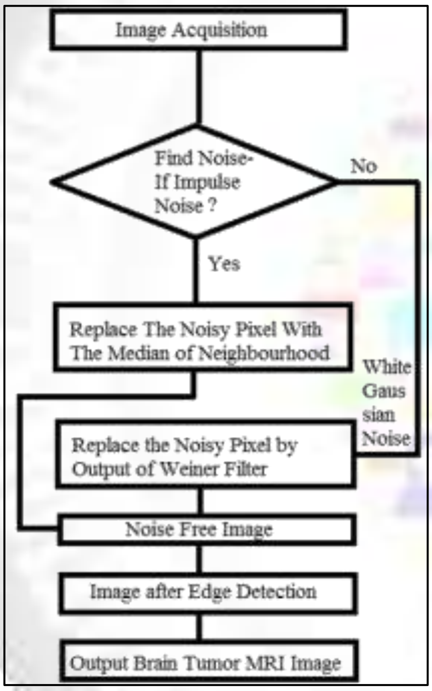

Fig. 1: Flowchart

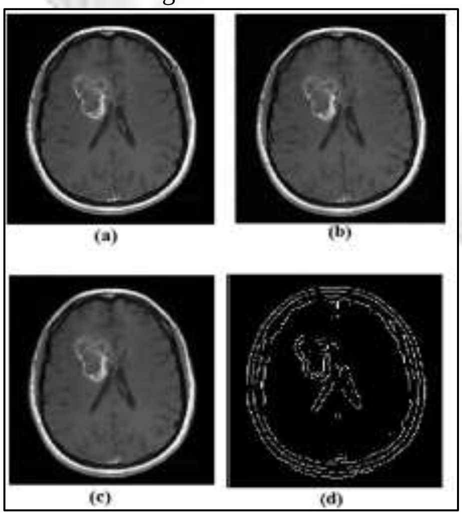

Fig. 2: (a) Original image (b) Image with added random Gaussian noise (c) Filtered image using above algorithm (d) segmented image using Canny Edge Detection algorithm.

V. EXPERIMENTAL RESULTS

MR Image	MSE (db)	PSNR (db)	RMSE
MR Image with added stochastic white Gaussian noise	100.25	28.15	10.01
MR Image after filtering using Median Filter (3X3)	20.89	34.96	4.57
MR Image after filtering using Average Filter (3X3)	18.11	35.60	4.26
MR Image after filtering using Wiener Filter(3X3) on Image with added white Gaussian noise	16.21	36.07	4.03
MR Image after using proposed filter method	6.36	40.13	2.52

Table 1: Experimental Results

REFERENCES

[1] Ehab F. Badran, Esraa Galal Mahmoud, and Nadder Hamdy, “An algorithm for detecting brain tumors in MRI images”, 978-1-4244-7042-6/10/$26.00 @ 2010 IEEE.

[2] Millee Panigrahi*1, Rina Mahakud*2, Minu Samantaray *3, Sushil Kumar Mohapatra *4, “ Comparative analysis of different Edge detection techniques for biomedical images using MATLAB”, Engineering and Scientific International Journal (ESIJ) Volume 1, Issue 1, October - December 2014

[3] Pratibha Sharma, Manoj Diwakar, Sangam Choudhary, “Application of Edge Detection for Brain Tumor Detection”, International Journal of Computer Applications (0975 – 8887) Volume 58– No.16, November 2012

[4] B.B.S.Kumar, Dr.P.S.Satyanarayana, Rohini G.V, “Brain Tumor Image Edge & Watershed Segmentation and Denoising Using DWT”, International Journal of Scientific & Engineering Research, Volume 5, Issue 11, November-2014

[5] “The essential guide to brain tumours”, National brain tumour society (NBTS), 2007. www.braintumor.org/upload/contents/330/GuideFINAL 2007.pdf

[6] Anisha, S.R PG Scholar,2Dr J Venugopala Krishnan, “Comparison of Various Filters for Noise Removal in MRI Brain Image”, International Conference on Futuristic Trends in Computing and Communication (ICFTCC-2015)

[7] Robert D. Nowak, “Wavelet Based Rician Noise Removal For Magnetic Resonance Images”, Submitted to IEEE Transactions on Image Processing August 1997 Revised January 1998.

[8] Mr. Rohit Verma, Dr. Jahid Ali, “A Comparative Study of Various Types of Image Noise and Efficient Noise Removal Techniques”, International Journal of

Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 10, October 2013.
[9] Sivasundari .S[1],R.Siva Kumar[2], M.Karanan[3] , "Performance Analysis Of Image Filtering Algorithms For MRI Images", IJRET Volume03 Issue: 05 May 2014.
[10] Dipankar Ray, D Dutta Majumder, Amit Das, "Noise Reduction and Image Enhancement of MRI using Adaptive Multiscale Data Condensation", 1st Intl Conf. on Recent Advances in Information Technology |RAIT – 2012, 978-1-4577-0697-4/12/$26.00 c IEEE.
[11] S. Aja-Fern´andez, A. Trist´an-Vega, "A Review on statistical noise models for Magnetic Resonance Imaging", Tech Report of the LPI, LPI, ETSI Telecommunication, Universidad de Valladolid, Spain, Email: sanaja@tel.uva.es, atriveg@lpi.tel.uva.es, TECH -LPI2013-01, Universidad de Valladolid, Spain, Jun. 2013. www.lpi.tel.uva.es/santi
[12] María G. Péreza, Aura Concib, Ana Belén Morenoc, Víctor H. Andaluza and Juan A. Hernándezd, "Estimating the Rician Noise Level in Brain MR Image", CAPES agency for founding in part the Brazilian author of this work. UTA-Ecuador Research Project 2340-CU-P-2013.
[13] Mary Gaskill-Shipley, "How To Read Your MRI", MD. Department of radiology/ neororadiology, University of Cincinnati.
[14] Ms. V. Kavitha, Dr. M. Renuka Devi, "A Hybrid Filtering Technique for Denoising the Citrus Fruit Images", International Journal of Applied Engineering Research ISSN 0973-4562 Volume 11, Number 7 (2016) pp 4746-4750.
[15] Chri Chris, "Chapter:3 Filters".
[16] Ajay Kumar Boyat1 and Brijendra Kumar Joshi2, "A REVIEW PAPER: NOISE MODELS IN DIGITAL IMAGE PROCESSING", Signal & Image Processing : An International Journal (SIPIJ) Vol.6, No.2, April 2015
[17] Albert Macovski, "Noise in MRI", Copyright *0* 1996 by Williams & Wilkins.
[18] http://in.mathworks.com/matlabcentral/
[19] http://www.mathworks.com/examples/matlab/community/
[20] http://in.mathworks.com/help/images/