HYBRID APPROACH FOR NOISE REMOVAL AND IMAGE ENHANCEMENT OF BRAIN TUMORS IN MAGNETIC RESONANCE IMAGES

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ABSTRACT

In medical image processing, Magnetic Resonance Imaging (MRI) is one of significant diagnostic techniques. It provides high quality of important information about the analysis of human soft tissue when measured with CT imaging modalities; hence it is suitable for diagnosis at best. However, if it gives quality of information, image may distorted by noise because of image acquisition device and transmission. The noises in MR image reduces the quality of image and also damages the segmentation task which can lead to faulty diagnosis. Noises have to reduce at the same time there is no information loss. This paper propose a hybrid approach to enhance the brain tumor MRI images using combined features of Anisotropic Diffusion Filter (ADF) with Modified Decision Based Unsymmetric Trimmed Median Filter (MDBUTMF). ADF scheme provides a superior performance by removing noise while preserving image details and enhancing edges. MDBUTMF helps in image denoising as well as preserving edges satisfactorily when the noise level is high. The performance of this filter is evaluated by carrying out a qualitative comparison of this method with other filters namely, ADF filter, Modified Decision Algorithm, Median filter, MDBUTMF.

KEYWORDS

Anisotropic diffusion, Modified decision based Unsymmetric median, edge preserving smoothing, image denoising.

1. INTRODUCTION

Image denoising is most important procedure to displace the noise in an image that leads to deliver superior outcomes in an image processing. Commonly MRI technique gives high quality of an image compared with CT modalities. So that MRI is suitable for medical diagnosis. Even if MRI medical images gives high quality, are also distorted with some noises namely, speckle noise, salt and pepper noise and blur noise (unexpectedly patients shaking their heads while scan the brain) during its process of acquisition and transmission [1]. So denoising approach requires removing the noise from an image, which is related to further operation such as segmentation, classification etc. The most principal in image denoising is preserving the edges and fine details of an image through noise reduction [2].

DOI:10.5121/acij.2016.7208

Modified Decision Based Unsymmetric Median Filtering is applied to eliminate salt and pepper noise in the level of high noise density levels. And also it provides better outcomes both visually and quantitatively [3]. The drawback of denoising is to avoid edges smoothing which are very significant features of an observed image. The anisotropic diffusion approach becomes a useful tool for edge detection [4, 5], image enhancement [6], image smoothing [7, 8], image segmentation [9, 10], image restoration [11, 12] and to remove speckle noise in an image. The main aim is removing the noise in MRI images without loss of any quality information and preserving the edge features.

2. LITERATURE REVIEW

The standard Median Filter (MF) is effective only at low noise densities [13]. The drawback of this standard Median filter is, if the noise level is above 50% edge details of original image cannot be preserved by standard median filter. As well as Adaptive Median Filter (AMF) works well at low noise densities [14]. But in high level of noise the window size has to be increased which lead to blurring the image. And also these filters will not take into account the local features as an outcome of which details and edges may not recovered satisfactorily, particularly when the high level of noise. To conquer the above drawback, Decision Based Algorithm (DBA) is presented [15]. In DBA, image is denoised by applying a 33 window. If the value of processing pixel is 0 or 255 it is processed or else it is left unchanged. In this case, neighbouring pixel is applied for replacement. This repeated replacement of neighbouring pixel produces streaking effect [16]. To avoid this catch, Decision Based Unsymmetric Trimmed Median Filter (DBUTMF) is proposed [17]. At high noise densities, trimmed median value will not be acquired, if the selected window contains all 0's or 255's or both. For that, this algorithm does not give better outcomes at very high noise density. MDBUTMF procedure removes this drawback at high noise density and gives better results in both visually and quantitatively [18].The restoration of images is more suitable to find potential applications in various areas such as medical diagnostics, archaeology, satellite imaging, etc.

Anisotropic diffusion is employed for both image enhancement and denoising. Perona-Malik (PM) model which is the first anisotropic partial differential equation model was proposed by Perona-Malik in year 1990. This model makes use of anisotropic diffusion to filter out the noise [19]. In this model the rate of diffusion is managed by edge stopping function. The pitfall of this model is that the sharp edges and fine details are not preserved well using appropriate edge stopping function. Catte et al [20] suggested modified version of PM model as anisotropic diffusion model with Gaussian filter in 1992. In this model the image must be smoothened by convolving with Gaussian filter then the gradient to be computed. You et al. [21] gave an in-depth analysis of the behaviour of the PM anisotropic diffusion model by examining the anisotropic diffusion as the steepest descent method for to solve an energy minimization problem. In the name of get a more directional behaviour of the diffusion process, Weickert [22] proposed an approach that substitutes the scalar diffusion coefficient with a diffusion tensor. It directs the process of diffusion as reported by the directional information accommodated in the image structure. Weickert [23] further proposed a revised diffusion model by examining coherence structures of edges. Among all the edge detection function (such as Perona Malik, Weickert etc.), the tukey edge detection function is very efficient in preserving sharp edges and adequate fine details and optical quality of the restored image is established to be true [24].

3. PROPOSED WORK

The main objective of this work is removing the noises in the MRI brain images without loss of information. So we proposed a hybrid approach which is combined features of these two filters such as MDBUTMF and Anisotropic diffusion method. While image acquisition and transmission of MRI images corrupted by speckle noise, impulse noise. MDBUTMF is performed well with all kinds of impulse noise. Anisotropic diffusion also helps in both image denoising and image enhancement using appropriate tukey edge stopping function. In section 6 various edge stopping functions are analysed in terms of how efficient they are preserving the edges by smoothening. The outcome of hybrid approach denoised image is moved to measure the quality using different quality metrics with its original or input image. And mean while this approach is compared with other existing filters such as standard MF, DBA, AMF, MDBUTMF, and Anisotropic diffusion filter. How hybrid approach outcome is better than the other existing filters that discussed in section 6.

4. METHODOLOGY

In this hybrid approach two filtering procedures are used to remove noises at the same time preserve the potential edge feature by enhancing the edges of an image by smoothening operation. Combine features of the filters are, Modified Decision Based Unsymmetric Trimmed median Filter and Anisotropic diffusion with tukey edge stopping function.

4.1 Proposed approach for Image Denoising and Enhancement process

The procedure for MRI image denoising is given below:

Step 1: An input image is converting into gray scale image

Step 2: Converted gray scale image is resized into standard window size.

Step 3: Apply MDBUTMF for reducing the high density noises in an image.

Step 4: Then apply anisotropic diffusion filter with tukey edge stopping function for preserving edge details, despeckling and enhancing the images at the resultant image from Step 3.

Step 5: The denoised image moved into image quality measurement.

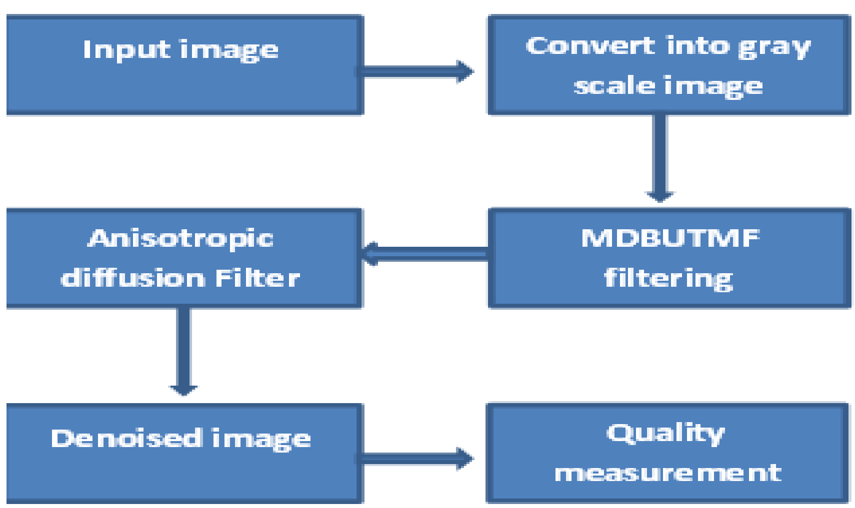

Fig 1: Block diagram in proposed approach for image Denoising and enhancement process

5. FILTERING TECHNIQUES IN HYBRID APPROACH

5.1 Modified Decision Based Unsymmetric Median Filter

Modified Decision Based Unsymmetric Trimmed Median Filter (MDBUTMF) processes the corrupted images by identifying the impulse noise. The processing pixel is confirmed whether it is noisy or not. That is, if the processing pixel lies between maximum and minimum values of gray level then it is treated as noise free pixel, it is left unchanged. If the processing pixel takes the maximum and minimum gray level then it is noisy pixel which is processed by MDBUTMF. The MDBUTMF steps are elucidated as follows.

Step 1: Select two-dimensional window size 3 by 3. Assume that the pixel being processed is p_{mn}.

Step 2: If $0<p_{mn}<255$ then p_{mn} is an uncorrupted pixel and its value is left unchanged.

Step 3: If $p_{mn}=0$ or $p_{mn}=255$ then p_{mn} is a corrupted pixel then the two cases are possible as given below.

- ***Case (i):*** If the selected window holds all the elements as 0's and 255's, then change with the mean of window element.
- ***Case (ii):*** if the selected window contains not all elements as 255's and 0's, then remove 255's and 0's and discover the median value for the rest of remaining elements. Replace p_{mn} with median value.

Step 4: Repeat steps from 1 to 3 till all the pixels in an entire image are processed.

5.2 Anisotropic Diffusion Filter

The Resultant image of above MDBUTMF is given as an input image to ADF. This filter provides a superior performance by removing noise while preserving image details. And it allows smoothing image at homogeneous areas without blurring edges. Here we follow the algorithm of anisotropic diffusion with tukey edge stopping function.

Basically in AD scheme, a good edge-preserving behavior is depends upon the selection of right conductance function. Kamalaveni et al [27] suggested that the tukey edge detection function is very efficient in preserving sharp edges, fine details and visual quality of the reconstruct image is base to be true. But edge stopping function is unable of denoising efficiently. To overcome this drawback, Gaussian filter is used to filter out the noise.

$$g(\|\nabla(G_\sigma * I(x,y,t))\|)$$

Where G_σ is a Gaussian filter of scale σ. This means that the local gradients that are the parameter of edge stopping function are also calculated using a smoothed version of the image in every iteration.

6. EXPERIMENTAL RESULTS AND ANALYSIS

6.1 Image Quality Specification for Result Analysis

Image Quality Measurement (IQM) is mandatory process in the expansion of image processing algorithms such as denoising, deblurring etc. as it can be helped to determine their performance in terms of quality of processed output image. In image processing, the image quality parameters are used for the assessment of imaging system. The quality of the denoised image may be tested by exploiting the distinction between the corresponding pixels in test and denoised output images. The Mean Squared Error, Average Difference, Peak Signal to Noise Ratio, Maximum Difference, Normalized Absolute Error, Normalized Cross Correlation instances of IQM are used to calculating the heterogeneous between two images on the premise of differentiating the corresponding pixels of the pair of input and denoised output images.

6.1.1 Mean Squared Error (MSE)

The average squared difference between the input and output denoised image is referred as Mean Square Error. It is defined as,

$$\text{MSE} = \frac{1}{MN}\sum_{j=1}^{M}\sum_{k=1}^{N}\left(x_{j,k}\ x'_{j,k}\right)^2$$

The tested image quality should have MSE values as the lowest error rate. Where x denotes the original image, x' denotes denoised image and M and N denotes the number of rows and columns in an image.

6.1.2 Peak Signal-to-Noise Ratio (PSNR)

Peak Signal-to-Noise Ratio (PSNR) is the correlation between the maximum possible signal power and the corrupting noise power that disturbs the reliability of its representation. PSNR is the estimation standard of the restored image quality. PSNR represents an estimate of peak value of the error. If MSE is zero, then PSNR is infinity. This means that a high value of the PSNR gives high quality of an image. It is given by,

$$\text{PSNR} = 10 \log \frac{(2^n-1)^2}{MSE}$$

Where 255 is possible value as maximum, that can be accomplished by the image signal and MSE is mean square error. Where x denotes the original image, x' denotes denoised image and M and N denotes the number of rows and columns in an image.

6.1.3 Normalized Cross Correlation (NCC)

Normalized Cross Correlation computes the correlation features between the pixels of original input and reconstructed images. The range of NCC is 0 to 1, very near to or the best value is 1. It is represented as,

$$\text{NCC} = \sum_{j=1}^{M}\sum_{k=1}^{N} x_{j,k} \cdot x'_{j,k} \Big/ \sum_{j=1}^{M}\sum_{k=1}^{N} x^2{}_{j,k}$$

Where x denotes the original image, x' denotes denoised image and M and N denotes the number of rows and columns in an image.

6.1.4 Normalized Absolute Error (NAE)

NAE interprets the difference between the inferred or measured value of quantity and its actual value. If the value of Normalized Absolute Error has larger value, that image is treated as poor quality image. It is expressed as,

$$NAE = \sum_{j=1}^{M}\sum_{k=1}^{N}|x_{j,k} - x'_{j,k}| / \sum_{j=1}^{M}\sum_{k=1}^{N}|x_{j,k}|$$

Where x denotes the original image, x' denotes denoised image and M and N denotes the number of rows and columns in an image.

6.2 Experimental Results

Different types of edge stopping functions in ADF are applied to various brain images. Among these functions tukey edge stopping function has higher PSNR value, lower value in MSE and NAE as well as the value of NCC is near to 1 which is examined as a leading result. Quality specification of tukey edge stopping function in ADF is shown in below table 1 and 2 for the image 1 and 2 respectively.

Figs 2, Fig 3 are the graphical representation of quality metrics at various edge stopping functions in ADF for Table 1 and Table 2 respectively.

Table 1: Image1 quality measurements of various edge stopping functions

ESF/ IQM	Perona	Normtuckey	Tuk Coherence	Norm Coherence	Coherence	Tukey
PSNR	74.0560	75.9655	75.9360	82.6891	89.5419	99.3328
MSE	0.0026	0.0016	0.0017	3.50E-04	7.23E-05	6.02E-06
NCC	0.9353	0.9529	0.9506	0.9909	0.9993	0.9993
AD	-3.55E-04	-3.78E-04	-4.56E-04	-3.46E-04	-1.16E-04	-2.97E-05
MD	0.3964	0.3752	0.3753	0.2076	0.1721	0.0657
NAE	0.1283	0.1045	0.0997	0.0300	0.0072	0.0031

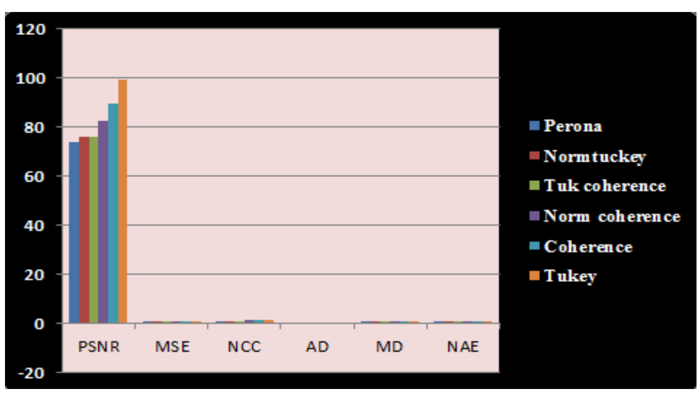

Fig 2: Comparison of various edge stopping functions in ADF for image1

Table 2: Image2 quality measurements of various edge stopping functions

ESF/ IQM	Perona	Normtuckey	Tuk Coherence	Norm Coherence	Coherence	Tukey
PSNR	73.8660	75.1922	75.0508	81.144	90.3595	99.1707
MSE	0.0027	0.0020	0.0020	5.00E-04	5.99E-05	7.87E-06
NCC	0.9353	0.9529	0.9506	0.9909	0.9993	0.9990
AD	--1.93E-04	--3.23E-04	--6.30E-04	-4.12E-04	1.47E-04	-3.27E-05
MD	0.4385	0.435	0.4172	0.4107	0.1833	0.0841
NAE	0.1234	0.1065	0.104	0.0322	0.0060	0.0033

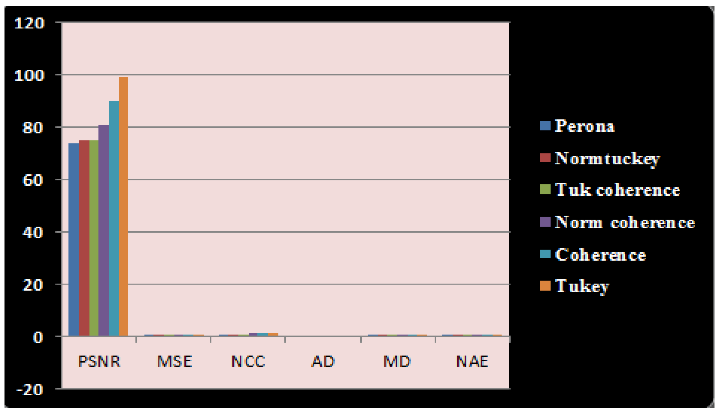

Fig 3: Comparison of various edge stopping functions in ADF for image2

The different MRI brain tumor images are converted as gray scale image. Then these images are denoised by various edge stopping functions in ADF. And the sample results are shown in below Figures to the image Tumor001 and Tumor002.

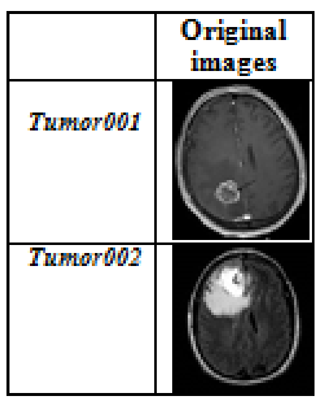

Fig 4: Input gray scale images

The input gray scale images (Tumor001, Tumor002) are shown in Fig 4. different edge stopping functions in ADF are applied to those images. And result is shown in Fig 5. Among these outcomes tukey edge stopping function has superior results by image quality measurements while preserving edge details and noise reduction. And it provides smoothened image edges without blurring.

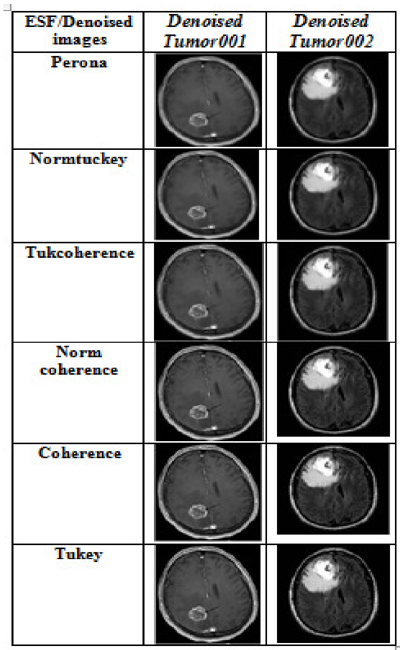

Fig 5: Output for various Edge Stopping Functions in ADF for the image Tumor001 and Tumor002.

Various filters are taken with hybrid method to compare with the quality measures of various quality metrics. From this observation outcome, hybrid method are providing better outcomes. Then the statistical reports for the image Tumor001, Tumor002 are shown in below Table 3 and 4.

Table 3: Image quality measurements of hybrid approach for the image Tumor001.

Filter/IQM	**PSNR**	**MSE**	**NCC**	**AD**	**MD**	**NAE**
SMF	32.4531	36.9637	0.9889	0.0835	80	0.0520
AMF	24.4175	235.1411	0.9978	-0.8350	88	0.0364
DBA	40.4711	5.8341	0.9984	0.0184	67	0.0078
MDBUTMF	41.5970	4.5017	0.9985	0.0161	74	0.0066
ADF	71.8133	0.0043	1.0074	-0.0316	0.3703	0.2572
Proposed	77.4485	0.0012	0.9664	6.3038e-05	0.4079	0.0989

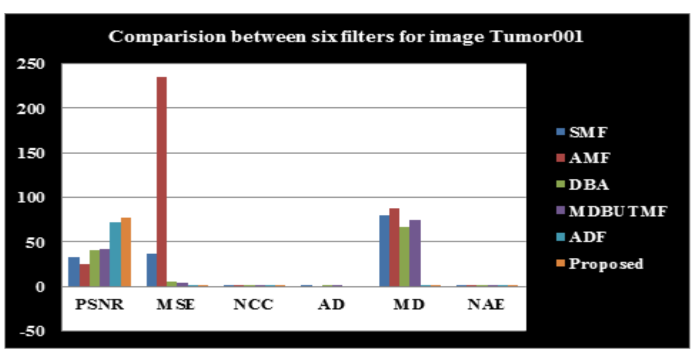

Fig 6: Graphical representation of Table 3 for image Tumor001

Table 4: Image quality measurements of hybrid approach for the image Tumor002.

Filter/IQM	PSNR	MSE	NCC	AD	MD	NAE
SMF	31.4949	46.0881	0.9833	0.3462	176	0.0687
AMF	23.5321	288.3161	0.9948	-1.0621	132	0.0482
DBA	37.8826	10.5881	0.9973	-0.0977	95	0.0150
MDBUTMF	37.2604	12.2193	0.9976	-0.2910	73	0.0167
ADF	70.3194	0.0060	0.9488	-0.0335	0.4120	0..3504
Proposed	74.4890	0.0023	0.9402	-0.0011	0.4492	0.1597

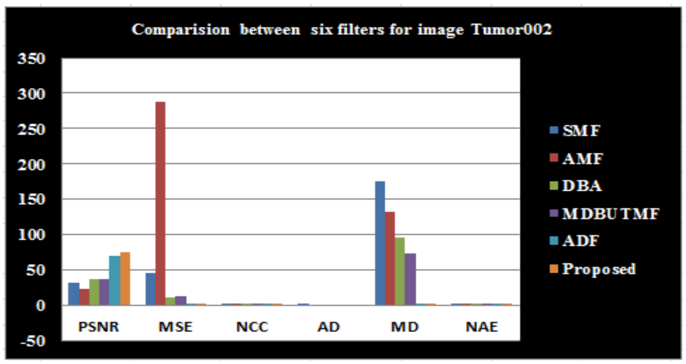

Fig 7: Graphical representation of Table 4 for image Tumor002

The outcomes of MRI brain tumor images are denoised using hybrid approach and these sample images are shown in below Figure 8.

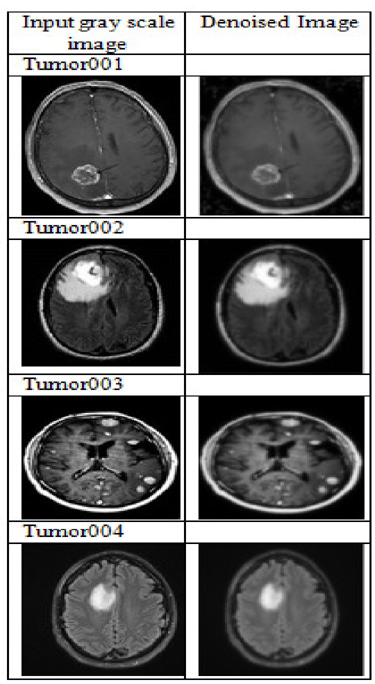

Fig 8: Denoised Images of various MRI brain tumor images using Hybrid approach

7. CONCLUSION

The results obtained using hybrid approach is applied at the different brain tumor MRI images. Quality assessment of hybrid method also compared with the other kind of filtering techniques. And it is estimated clearly and proved from the statistical assessments of this work the hybrid approach gives better results. This hybrid approach has good performance by removing noise, perceptual quality, and preserving the edge details without blurring in all images. Combination of this technique works better for all images compare with other technique.

ACKNOWLEDGEMENT

I would like to thank Dr. K. Perumal, Associate Professor, Department of Computer Applications, School of Information Technology, Madurai Kamaraj University, Madurai, Tamilnadu, for his guidance and support provided throughout the work.

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