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Novel Approach For Noise Removal of Brain Tumor MRI Images

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ABSTRACT

In Image processing, Image denoising becomes mandatory for many applications. In medical imaging, An MRI (Magnetic Resonance Imaging) image provides high quality when estimated with CT imaging techniques and hence it is best suited for diagnosis. Even though it's providing high quality informations, images may corrupted by noise due to acquisition and transmission. Noises have to remove while the mean time there is no loss of information and also have the capability to preserve edges. This paper presents a novel approach for denoise the brain tumor MRI images using combine features of Stationary Wavelet Transform (SWT), median filter and sharpening filter. Accordingly, this approach is intended to develop for the noise removal with the edge preserving qualities in brain tumor MRI images. In Wavelet, SWT shows a superior performance in denoising because of its multi-resolution property and no signal leakage. Median filter helps in preserving edges and edges are enhanced by sharpen filter .And the results are compared using some image quality factors to find out the similarity with the original images.

Key words —Wavelet transform, Image denoising, Sharpen filter, Median filter.

1 Introduction

Image denoising is the most significant steps to remove the noise in an image that leads to provide good results in an image processing. Normally MRI images provide high quality when compared to CT (Computed Tomography) imaging techniques. So it is best suited for medical diagnosis. Even if an MRI image provides high quality that is also corrupted with some noises such as impulse noise, speckle noise, blur noise (unexpectedly patients shaking their heads during scanning the brain) during acquisition and transmission [14]. So denoising technique is needs to remove the noise from the image, which is applicable for further processing such as segmentation, classification, etc. Moreover edges are important features for MRI images. The most important in image denoising is to preserve the edges and all fine details of an image during noise reduction [10].

Median filtering is used to remove salt and pepper noise because of its effective noise suppression capability and computational efficiency. This filter tends to preserve edges during filtering. However, this median filter is performed poorly in the presence of signal dependent noise [9]. Wavelet transform is a tool for denoising the image. It endeavors to remove the noise present in the signal while preserving the characteristics of signal of its frequency content. This work contains various wavelet types with median filtered image and that are used for sharpen filter to enhance the edge features of an image [12].

Wavelets being used more and more because that are capable of deconstructing complex signals into basis signals of bandwidth and then reconstructing it again with very little loss of information [1].

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Particularly this means there is little to no signal leakage of phase-shifting of the original signal when decompose it. Conventional filters generally have problems with signal leakage of phase-shifting that have to be dealt with least acknowledge in the output. The SWT is designed to overcome the drawbacks of DWT. So this SWT is used for denoising the brain images. The main objective is to remove noise in MRI images without loss of any information and preserve edge features.

2 Literature Review

Kanwaljeet Kaur et.al [5], worked with the spatial filter like median [8] and weiner filter, etc. and disadvantage of median filter is the extra computation time needed to sort the intensity value of each set. Rong Zhu et al [9] has discussed about various median filtering techniques and which filters works well with the noise and which filter having edge preserving quality while removing noise and they proposed improved median filtering techniques that works well than other filters. It smoothen the edge information to overcome this drawback Abdulla Al Juma [1] worked with wavelet transform is used to remove the noise information in the signal without loss of image originality [6]. Jaspreet kaur et al [4] proposed a novel approach to denoising the speckle noise in ultrasound images using DWT and that is used for FCM based segmentation. Here the drawback is time invariant and loss of information due to down sampling to overcome these drawback S.Janani et al [3] worked with the SWT filter. There is no sub sampling so no loss of its originality. They processed a new approach for segmentation based on SWT and FCM. Mirajkar PradnyaP, et al [6], V N Prudhvi Raj, et al [7] worked with wavelet transform for denoising and image fusion. Rupinderpal Kaur, et al[10] worked with denoising the medical images using DWT. Soundarya K [13] worked with the SWT based noise removal using video processing images. A. Velayudham et al [14] has been worked with medical image denoising [15]. Types of noises corrupted the medical images which denoising techniques are provided good denoised images that are researched by them. Quality assessment of spatial filtering techniques has been discussed [11] and various types of quality metrics used to measures the dissimilarity between the input images and denoised images are also discussed in [2] and region based segmentation is used to extract the brain tumor images along with the morphological operator.

3 Proposed Work

The main intention of the work is to reduce noises in the MRI images without loss of information. So, for this work we proposed a novel approach that is combined features of three filters such as median filter, SWT and Unsharp masking filter. Basically MRI images may corrupt salt and pepper noise during acquisition and transmission. Median filter is well performed with all types of impulse noise. Wavelets help denoising the image without loss of its originality. So Wavelet based denoising technique is applied in the gray image. Although these filters are removing noises and also preserve edges of an image that also need to enhance the edges so, sharpen filter is used. The result of novel approach denoised image is used to measure the quality using various quality metrics with its original image. During quality measurements dissimilarity of the pixels of denoised image is identified. And the novel approach is compared with the existing filters of median filter and the combinations of median and SWT filters and how the novel approach result is better than other filters results that discussed.

4 Methodology

In this novel approach three types of filtering techniques are used to remove noises while the mean time enhances the edges of an image. The denoised image has got from original image subtracted with noise. So it can preserve edge features. Combine features of the filters such as

- Median Filter
- SWT Filter
- Unsharp Filter

4.1 Denoising Procedure:

The procedure to denoise an image is given as follows:

- Step1: Convert input image into grayscale image with standard window size.
- Step2: Apply Median Filter to the MRI brain image.
- Step3: Apply stationary wavelet transform with the image.
- Step4: Decompose the image to remove noise.
- Step5: Apply inverse Stationary Wavelet Transform to get a denoised image.
- Step6: Combine the result of median and SWT filters
- Step7: Apply Unsharp masking filter with the combined denoised image.

Denoised Image g(x,y) = Original Image f(x,y) – noise η(x,y)

Obtain a sharp image by subtracting a lowpass filtered(i.e., smoothed) image from the denoised image:

Enhanced denoised image = DenoisedImage – smoothed information

Over all block diagram of the work is shown in figure 1

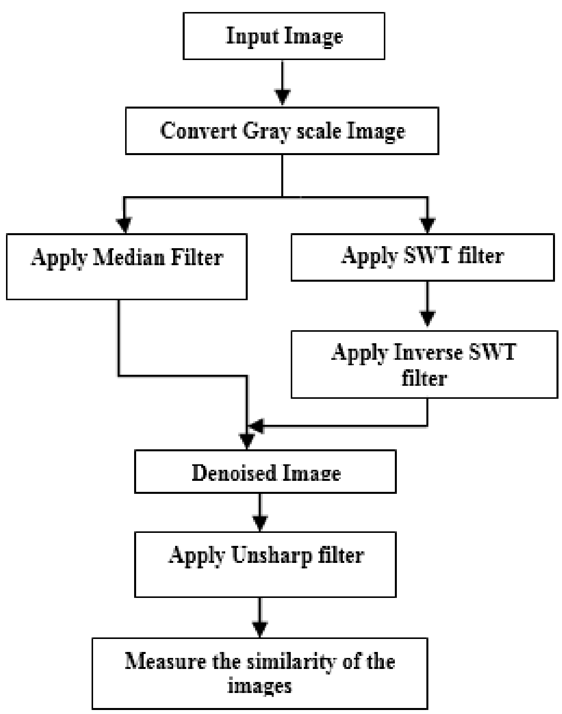
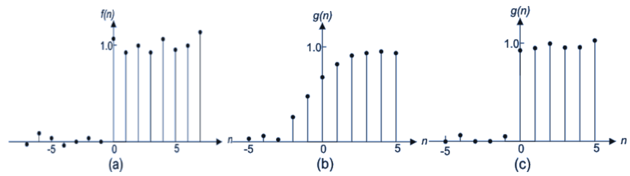


Figure 1: Block diagram of the denoising using combinations of filters.

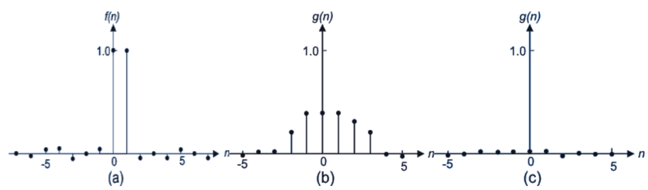
5 Novel Approach Filtering Techniques

5.1 Median Filter

MRI image may corrupted by salt and pepper noise and random valued noises. Noises may arise due to the changes of transmission of an image. Median filtering is a nonlinear process useful in reducing impulsive or salt-and-pepper noise. It is also useful in preserving edges in an image while reducing random noise [2, 5]. Impulsive or salt-and pepper noise can occur due to a random bit error in a communication channel. 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 of the pixel being processed.



(i)



(ii)

Figure 2: (i,ii) Filtering the 1D signal with 5 point median filter

Like lowpass filtering, median filtering smoothes the image and is thus useful in reducing noise. Unlike lowpass filtering, median filtering can preserve discontinuities in a step function and can smooth a few pixels whose values differ significantly from their surroundings without affecting the other pixels. Figure (2(i)a) shows a 1-D step sequence degraded by a small amount of random noise. Figure (2(i)b) shows the result after filtering with a lowpass filter whose impulse response is a 5-point rectangular window. Figure (2(i)c) shows the result after filtering with 5-point median filter. It is clear from the figure that the step discontinuity is better preserved by the median filter. Figure (2ia) shows a 1-D sequence with two values that are significantly different from the surrounding points. Figures (b) and (c) show the result of a lowpass filter and a median filter, respectively. The filters used in figure (2(ii)) are the same as those used in figure (2(i)). If the two impulsive values are due to noise, the result of using a median filter will be reducing the noise. If the two values are part of the signal, however, using the median filter will distort the signal. To prevail over this problem go for wavelet transform.

5.2 Wavelet Transform

Wavelet transform is a tool to represents the image in multiple resolutions. Wavelet transform is used for denoising the signal frequency. So loss of information is avoided. The computation of an image requires filtering and sub-sampling. In each level of sub sampling there are three detail images such as horizontal, vertical, and diagonal informations in high frequency [1]. The decomposition allows a perfect reconstruction of the original image. There are various types of wavelet transforms among them SWT is the improved version of DWT.

In DWT there is up and down sampling to denoising the image, so information may loss due to down sampling. The stationary wavelet transform is designed to overcome the disadvantages of discrete wavelet transform such as sub sampling the image, there is no translation invariant. There is no down sampling take place between levels. This provides better time frequency localization. DWT and SWT process designed diagram is shown in figure 2.

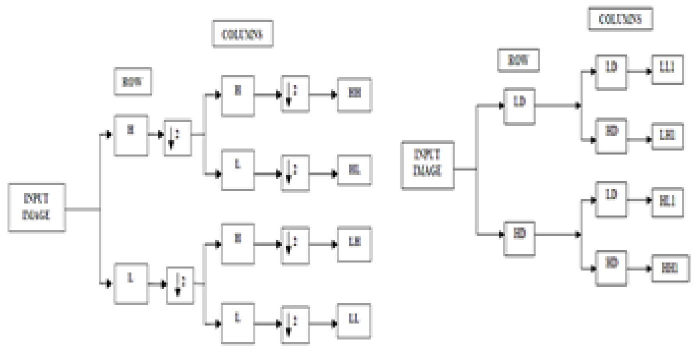


Figure 3: Filter bank structure of the DWT & SWT.

Wavelet decomposition preserved and depicted the sharp transition in images, which results in very accurate denoising in images. So there is no loss of information. These properties of the stationary wavelet transform make the image effective for denoising. Now-a-days multi resolution wavelet denoising techniques are used such as haar, daubechies, Symlet, coiflets, orthogonal and bi-orthogonal [4]. Wavelet thresholding approach is sensitive to denoising. There is two thresholding hard and soft. In hard thresholding, All co-efficient whose magnitude is greater than the selected threshold value that remains same and the other whose magnitude is smaller than the threshold value are set to zero. In soft thresholding all co-efficient who magnitude is greater than the selected threshold value are shrunk towards zero by an amount of threshold and others set to zero. Inverse transform is used to reconstruct the denoised image after decomposition of the original image. The result of median and SWT filters are combined for edge enhancements. The SWT filters process flow diagram is mentioned in figure3.

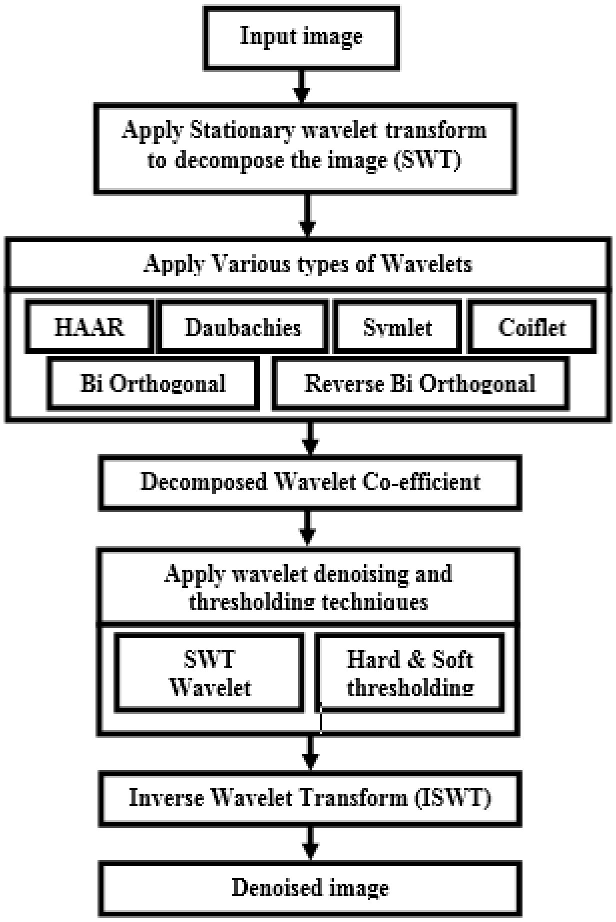


Figure 4: Process flow diagram for SWT denoised Image.

5.2.1 Unsharp Masking

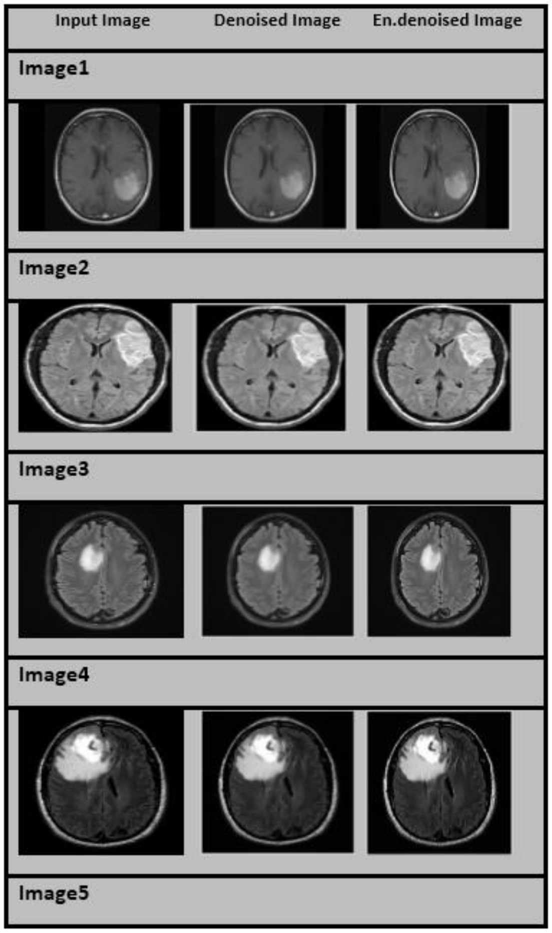
Digital unsharp masking is a flexible and powerful way to increase the sharpness, especially in scanned images. Unfortunately it may create unwanted conspicuous edge effects, or increase image noise. However, these effects can be used creatively, especially if a single channel of an image is sharpened. Undesired effects can be reduced by using a mask [12].

6 Experimental Results and Analysis

6.1 Experimental Results

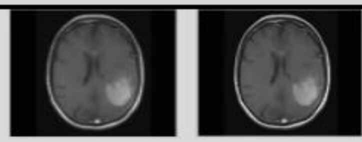
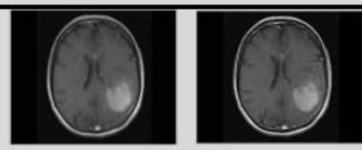
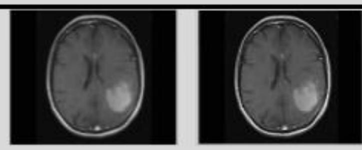
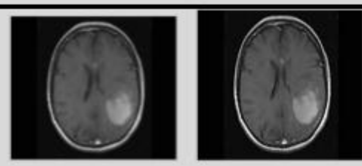
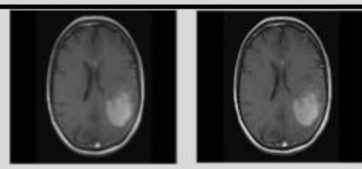
MRI brain tumor images are taken as an input image. In the 2nd column of denoised images are combine features of Median and SWT filters. Images which are in the En.denoised images are the results of novel method. These results are shown in table 1. From this result haar transform works better with this novel approach. The statistical measurement is shown in table 3.

Table 1: Denoised images of various MRI brain Images using Haar wavelet transform.

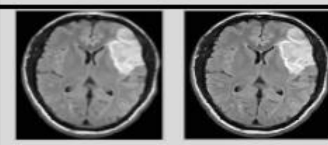
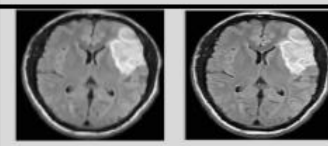
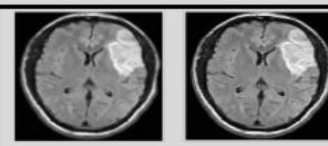
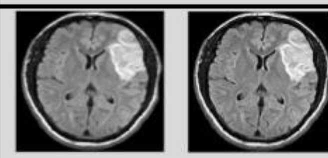
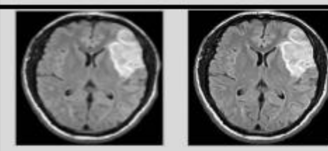


In table 2, MRI brain tumor images are compared with various types of wavelet techniques. Image1 and Image2 are taken as an input image from table 1. Column 2-denoised images are the result of combined features of median and SWT filters. Column 3-En.denoised images are the result of edge enhanced denoised images with various wavelet techniques. Among this which wavelet transform is working well with novel approach that statistical report is given in table 4 and 5.

Table 2: a, b are Various wavelet techniques used for denoising the different MRI images.

Wavelet types	Image1
Daubachies Transform	
Symlet Transform	
Coiflet Transform	
Biorthogonal Transform	
Reverse Biorthogonal Transform	

(a)

Wavelet types	Image2
Daubachies Transform	
Symlet Transform	
Coiflet Transform	
Biorthogonal Transform	
Reverse Biorthogonal Transform	

(b)

6.2 Image Quality Parameters for Analysis

Image Quality Measurement (IQM) is essential in the development of image processing algorithms such as deblurring, denoising etc. as it can be used to estimate their performances in terms of quality of processed image. In image processing, the image quality parameters are applied for the evaluation of the imaging system. In fact, in image enhancement system, the truly characteristic measure of image quality is perceptual quality.

The quality of the output image can be tested by exploiting the differences between the corresponding pixels in the test and the output images. Average Difference (AD), Maximum Difference (MD), Normalized Absolute Error (NAE), Signal-to-Noise Ratio (SNR), Mean Square Error (MSE), Mean Absolute Error (MAE), Peak Mean Square Error (PSNR), Structural Content (SC) and Normalized Cross Correlation (NCC) are examples IQM measures. These measures measure the dissimilarity between the two images on the basis of comparing the corresponding pixels of the two images.

6.2.1 Mean Squared Error (MSE)

Mean Squared Error (MSE) is the average squared difference between input and denoised output image. The error is the amount by which the value obscure by the estimator differs from the quantity to be estimated. The image quality parameters used in this work for comparing the denoised result with the original image. It is expressed as

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

Where x is the original image and x′ is the denoised image, Where M and N is number of rows and columns of the image. The quality of the tested image should have MSE values lower as the lowest error rate, so that it is having good result [12].

6.2.2 Peak Signal-To-Noise Ratio (PSNR)

Peak signal-to-noise ratio (PSNR) is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the reliability of its representation. PSNR is the evaluation standard of the reconstructed image quality. The PSNR represents a measure of the peak value of the error. If MSE is zero, then PSNR is infinity. This means that a high value of the PSNR provides a higher image quality [12]. Similarly, the smaller value of the PSNR implies that the difference between the images is larger and the image quality is lower. It is expressed as

$$PSNR = 10 \log \frac{(2^n - 1)^2}{MSE} = 10 \log \frac{255^2}{MSE}$$

Where255 is maximum possible value that can be attained by the image signal and MSE is mean square error, using this only PSNR will be calculated.

6.2.3 Normalized Cross Correlation (NK/NCC)

Normalized Cross Correlation is a measure of similarity of two images as a function of a time-lag applied to any one of them. It is co relational based quality measure which normally looks at correlation features between the pixels of original and reconstructed image. Normally NK is in the range of 0 to1, very near to or one is the best. This is also known as a sliding dot product or sliding inner-product. It is expressed as

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

Where x is the original image and x′ is the denoised image, Where M, N are number of rows and columns of an image.

6.2.4 Normalized Absolute Error (NAE)

Normalized Absolute Error is the difference between the measured or inferred value of a quantity and its actual value. The large the value of NAE means that image is poor quality. It is given by

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

Where x is the original image and x′ is the denoised image, M and N is number of rows and columns of an image.

6.2.5 Structural Content (SC)

Structural count is actual difference between original and denoised image. It is co relational based quality measure which normally looks at correlation features between the pixels of original and reconstructed image. Normally SC is in the range of 0 to1, very near to or one is the best. SC is defined as

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

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

Quality measurements of table 3 images are compared with the original image to find dissimilarity between images. Quality measured values of those images are mentioned in the below tables.

Table 3: Quality measurements of various MRI brain images.

IQM/ Images	Image 1	Image 2	Image 3	Image 4	Image 5
MSE	44.0533	109.4396	70.6554	77.9763	59.0214
PSNR	87.7774	73.4776	68.2471	67.2612	70.0463
NCC	1.0347	1.0040	1.0070	1.0259	1.0242
AD	-1.0686	0.1630	-0.1806	-1.4602	-0.8766
SC	0.9181	0.9689	0.9712	0.9372	0.9419
MD	58	108	124	78	113
NAE	0.0213	0.0872	0.0929	0.1138	0.0868

From this table 3, the statistical measures of the PSNR values are higher than the MSE values. NCC & SC values are very close to 1, NAE values are low and MD, AD values are very favors so the novel approach gives the best result. Graphical based diagrammatic representation of above table is given in figure 5.

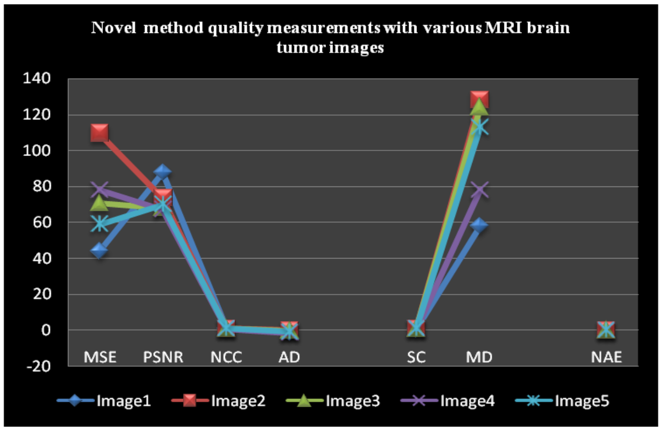


Figure 5: Novel method quality measurements with various brain tumor MRI images.

Different types of wavelet transforms are applied with the novel approach. This comparison made on many images, but here only two images (Image1, Image2) quality measurements are shown in table 4 and 5. Along with these wavelet transforms which technique contains the highest values of all these quality measurements except MSE is considered as a best result. Because that works well with the novel approach compared with other. From the result it is observes the haar wavelet transform gives better result than other wavelet transforms. So haar wavelet transform is used to decompose the image in SWT filter.

Table 4: Image1 Quality measurements of novel approach denoised image with various wavelet transforms.

IQM/ wavelets	Haar	DB	Smy	Coif	Bior	RBio
MSE	44.0533	59.8257	78.8209	79.2611	60.6547	70.8508
PSNR	87.7774	69.9109	67.1535	67.0978	69.7733	68.2195
NCC	1.0347	1.0401	1.0463	1.0465	1.0374	1.0367
AD	-1.0686	-1.9586	-1.1484	-1.1485	-1.0213	-1.0548
SC	0.9181	0.9123	0.8980	0.8976	0.9167	0.9154
MD	58	87	67	68	77	85
NAE	0.0213	0.0980	0.0916	0.0930	0.0841	0.0925

Figure 6 is the graphical representation of various types of wavelet transforms results with the given quality metrics in table4.

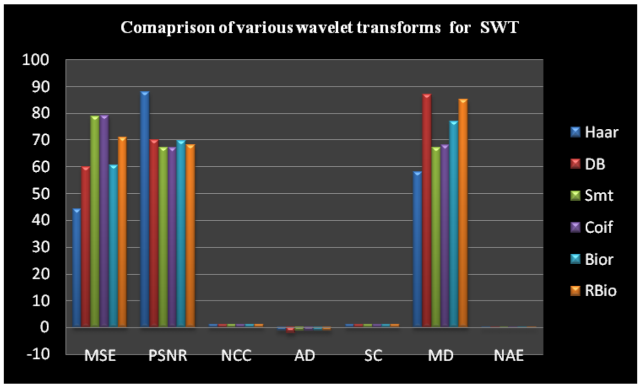


Figure 6: Comparison of various wavelets transforms.

Table 5: Image2 Quality measurements of novel approach denoised image with various transforms.

IQM/ Wavelets	Haar	DB	Sym	Coif	Bior	RBio
MSE	109.4396	271.1021	270.1382	266.3461	278.5668	300.0552
PSNR	73.4776	54.8003	54.8359	54.9773	54.5287	53.7856
NCC	1.0040	1.0081	1.0081	1.0082	1.0060	1.0054
AD	0.1630	-0.7024	-0.7170	-0.7076	0.2326	0.1042
SC	0.9689	0.9640	0.9640	0.9642	0.9673	0.9670
MD	108	223	205	197	218	245
NAE	0.0872	0.0813	0.0808	0.0804	0.0795	0.0871

Figure 7 is graphical representation for various wavelet techniques of SWT are compared and statistical report is given in table 5.

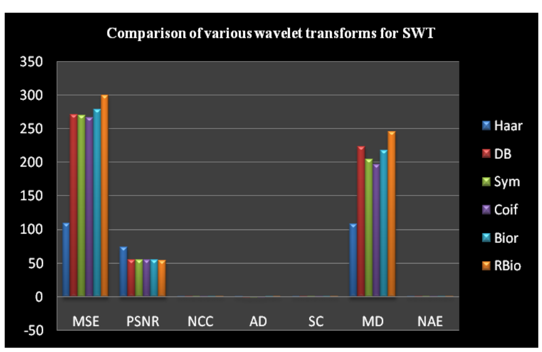


Figure 7: Comparison of various wavelets transforms.

The results of denoised image with three filtering techniques such as Median, Median with SWT filter and novel method filters are compared with the quality measures of various quality metrics. Among these wavelet transforms which technique contains the highest values of all these quality measurements except MSE is considered as a best result. From this result, it is observed that the denoised images of the novel method are providing better results.

Table 6: Quality measurements of denoised images based on median and SWT filters.

IQM/Filters	Median filter	Median & SWT filters	Novel method
MSE	88.9391	77.5264	44.0533
PSNR	73.9209	64.7788	87.7774
NCC	0.9899	0.9958	1.0347
AD	-1.1501	-1.8162	-1.0686
SC	1.0182	1.0049	0.9181
MD	98	83	58
NAE	0.0894	0.0516	0.0213

The statistical values of the quality measurements are among various filtering techniques are done of image1 and image2 are shown in table 6 and 7. And the graphical based diagrammatic representation of these two tables is given in figure 8 and 9. From these tables, it is observed that the quality measurements experimentally made between original and denoised image.

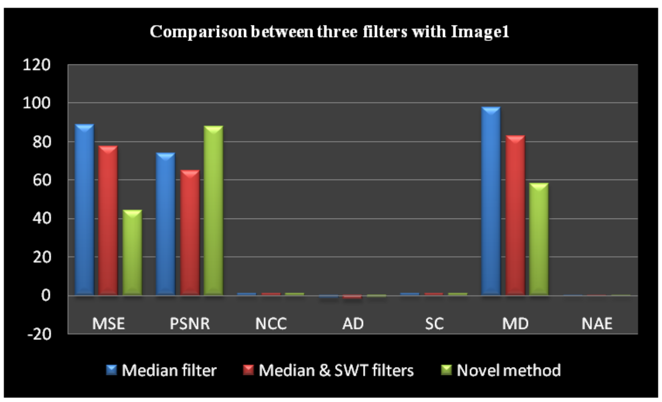


Figure 8: Comparison between three filters with image1.

Table 7: Quality measurements of denoised images based on median and SWT filters.

IQM/Filters	Median	Median & SWT	Novel method
MSE	399.7375	306.6644	109.4396
PSNR	67.8552	57.5143	73.4776
NCC	1.9811	1.9845	1.0040
AD	1.3117	0.3166	0.1630
SC	1.0227	1.0150	0.9689
MD	248	187	108
NAE	0.0949	0.0859	0.0872

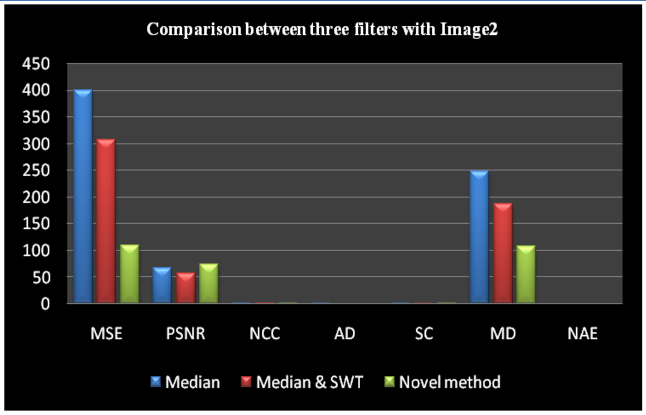


Figure 9: Comparison between three filters with Image2.

7 Conclusion

The results obtained using novel approach is applied in the various brain tumor MRI images and different types of wavelet transforms. This novel approach also compared with the various filtering techniques. It is clearly estimated and proved from the statistical measurements of this work that the novel approach is providing better results. So the denoising performance can be improved by choosing the better denoising techniques. The novel approach is produced the image with high perceptual quality and preservation of edge informations. From the overall work, it was verified that the single algorithm will never work better for all fields. In future, this approach is used for diverse applications.

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