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Enhanced De-Noising Technique for Region Growing Segmentation

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Abstract

Background/Objectives: In recent years, medical imaging plays an important role to detect diseases. Especially, Magnetic Resonance Imaging (MRI) images are indispensable for tumor detection. In medical image processing, the Region Based Segmentation (RBS) algorithms have attained an essentially significance to detect the tumor and are utilized for optimum results with the segregation of tumor part in the MRI image. The aim of the work is to provide effective algorithm to extract tumor and size, the process of de-noising technique, segmentation and extraction is the best way for this. At first, the enhanced de-noising method helps to enhance the MRI image to extract the tumor alone. **Methods/Statistical Analysis:** In image processing, automatic image segmentation plays a vital role and for RBS, the selection of seed has to done automatically to achieve this. Even if this technique is well performed with noises, the images are difficult to segment due to pixel similarity and the presence of noise. The noises can be removed by the combinations of median and Stationary Wavelet Transform (SWT) before preceding this, contrast enhancement is needed. In this paper, the combined features of de-noising technique are used for minimizing the effect of noises in the MRI brain images. After the process of de-noising, the segmented results will be a better one than non-de-noise (i.e. Original) images. The extracted tumor results are compared by the various quality metrics as MSE, PSNR, NCC, AD, NAE, SE etc. with the ground truth image. This enhanced de-noising technique is used to test 50 images and is performance evaluated based on their MSE and PSNR. **Findings:** The enhanced de-noising technique gives better result than existing de-noising technique. Thus, the tumor extraction can be done easily. **Improvements/Applications:** This technique is used mainly for medical imaging applications.

Keywords: Image De-noising, Image Segmentation, Median Filter, MRI, Region Based Segmentation, Stationary Wavelet Transform

1. Introduction

Image segmentation is the process of segregating the image into multiple regions based on the similar characteristics such as pixel intensity, texture or color. It is efficient to extract and represent the information from an image. Segmentation is classified based on region, edge, threshold, cluster. The RBS algorithm is a process of separating the image into multiple homogeneous regions under similarity of criterion among the sets of pixels. The region is iteratively grown by computing all unallocated neighboring pixels to the region[1]. The segmentation of brain MRI images classified into different classes as White Matter (WM), Gray Matter (GM), Skull, background and abnormal white tissues that are shown in Figure 1.

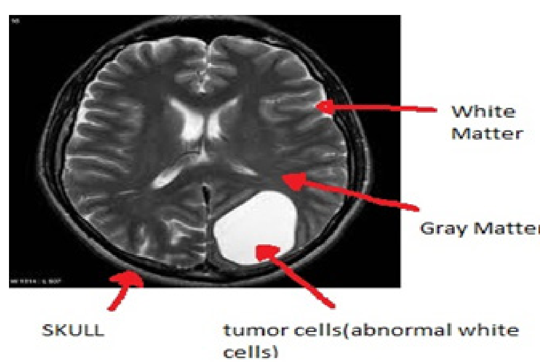

Figure 1. Different tissue classes of MRI brain image.

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The segmentation of brain tissues plays a vital role for numerous applications such as pathology diagnosis, surgical planning and guidance[2]. In Single Seed Region Growing (SSRG) segmentation[1–4], initial seed point selection made in different ways and in this segmentation if there is no human intrusion so it's called as Automatic Single Seed Region Growing algorithm (ASSRG). Regions are grown based on the seed point[5]. Image enhancement is needed for good segmentation. Even though the MRI images having clear soft tissue information than CT images, which may be affected by some types of noises. This is as for non-identical magnetic field, according to patient movement in imaging duration, impulse or salt and pepper noise, speckle noise[4], blurriness and other noises. It causes computational errors in habitual image analysis and brain tumor detection. Therefore it's absolutely necessary to remove noises from the image enhancement processing.

For the noise removal of MRI images, various de-noising techniques are used; particularly the wavelets can suppress noises which are out of frequency band signal[6,7]. Also it can do the same thing using conventional filters such as butterworth, chebyshev, etc. wavelets is 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. Particularly this means there is little or no signal leakage of phase-shifting of the original signal when decomposed it. Conventional filters generally have problems with signal leakage of phase-shifting that have to be dealt with least acknowledge in the output. The Stationary Wavelet Transform (SWT)[5,8,9] is the improved version of Discrete Wavelet Transform (DWT)[7], so SWT is used for de-noising[6] the brain images. The objective is to extract tumor and measure the area, number of tumor cells in the tissues. The combined features of median filters[2,10,11] and SWT are used. In general, MRI images are similar to black and white images so that it may be corrupted by salt and pepper noise. If the noise may present in the image then it is removed by the median filter[2,11,12].

In[2] proposed a novel approach to de-noising 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 drawbacks. In[3,5] worked with the ASSRG segmentation based on the seeded region growing selection; finally the tumor region has been successfully extracted. In[6] 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. In[7] worked with de-noising the medical images using DWT. In[8,9] worked with the SWT based noise removal using video processing images. In[10] proposed novel method for filtering the MRI images which gives clarity results. In[10] Proposed novel method for filtering the MRI images which gives clarity results. 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. In[13,14] worked with the spatial filter like median[14], wavelet transform for de-noising and image fusion and wiener filter, etc. and disadvantage of median filter is the extra computation time needed to sort the intensity value of each set. In[15] worked with wavelet transform is used to remove the noise information in the signal without loss of image originality. In[16] extraction of brain tumor in MRI images[17] and the implementation made with the help of Matlab. In[18] made on assessment of image quality in a spatial domain, its more helps to know the efficiency of the algorithms. In[19] worked with the segmentation technique and improved its features by the help of de-noising and contrast enhancement. Basically noises can be occurred in an image to suppress the noise by using image sharpening[20] is the method. Impulse noise[21] can be removed by the median filter. In this work types of noises may corrupted the medical images which de-noising and tumor area and number of pixels were affected or are in the tumor region has been calculated.

2. Proposed Work

The existing work is combined features of median, SWT and Unsharp filter. Practically it was working well for removing noises and the result is better than the filters used unaided. Thus, the result was taken for further process (i.e. segmentation). But it won't give a fruitful result during segmentation. So the work is moved to various combinations from that the combined features of SWT and median filter which is working well with contrast enhanced image.

In MRI images technically proved to showing clear tissues information according to digital conversion there is a need of contrast enhancement. This enhanced image may leads to good segmentation. Wavelet helps de-noising the image without loss of its originality. Wavelet shows a better-quality performance in de-noising since its multi-resolution property[2,7]. And the median filter helps to preserve edges, especially work well with the salt and pepper or impulse noisy image. These combined features of resultant de-noised image gives fruitful result with the ASSRG segmentation[1,4]. Purposely this segmentation is intended to detect the tumor and the result is used to measure the performance of the resultant image with various quality measurements.

3. Methodology

So the result of existing de-noised method hasn't worked well with ASSRG segmentation and is been improvised according to this segmentation. So this de-noising method is accordingly altered in favor of this work. Over all process of the block diagram is shown in Figure 2.

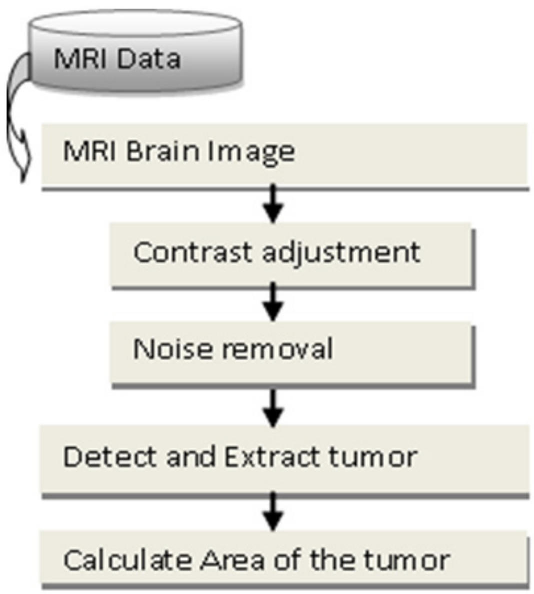


Figure 2. Block diagram for brain tumor extraction.

3.1 Input Image

The MRI brain tumor image is taken as an input image. For an uncomplicated purpose the input image is converted into gray scale image. Basically the transmitted digital images are in the color format and it has 3 channel bands. But for grayscale it has fewer channels than color image. So this type of image is have less complication and it contains the pixel range is from 0 to 255. In color image each channel contains the range from 0 to 255. Thus it can naturally compute better than the color image[3].

3.2. Improved Novel approach De-noising Method

The scanned images may corrupted by some types of noises due to transmission. Basically, it can be affected by low contrast, sharpness, salt and pepper noise, speckle noise, blurriness, etc. To remove salt and pepper noise and speckle noise, the existing approach of de-noising method is used which contains the combine features of median, SWT and Unsharp filters. However this approach has not attempted well with this segmentation because of Unsharp masking filter all edges was sharp and it expands the pixels. So, the extremely high intensity pixels are segmented alone among high intensity pixels. Therefore, this novel approach is modified using contrast adjustment instead of Unsharp filter[20]. Median and SWT filters are used to remove speckle noises[2]. Initially contrast will be enhanced.

3.2.1 Contrast Adjustment

Even though the MRI images are in the two dimensional image it looks like gray scale image. An image lacks in contrast, while there are no sharp variations between black and white pixels. In general, brightness refers to the lightness or darkness of an image. Towards to change or adjust the contrast of an image with the help of contrast adjustment tool which well performs contrast adjustment. This contrast technique follows some procedures:

- Select a mid-point of contrast from an image by using histogram.
- If mid-point is less than the pixel value, there is a no change in contrast.
- If mid-point is greater than the pixel, there is a need of contrast increment.
- The pixel values in between these two values are displayed as shades of gray.
- Repeat step 2 to 4 until it reaches end.

Which pixels satisfying the above constrains is a linear mapping of a pixel values to the entire range and producing an image of higher contrast. The above constrains are figured out in Figure 3. The lower limit and upper limit mark the boundaries of the window, displayed graphically as the pink window in the Adjust Contrast tool.

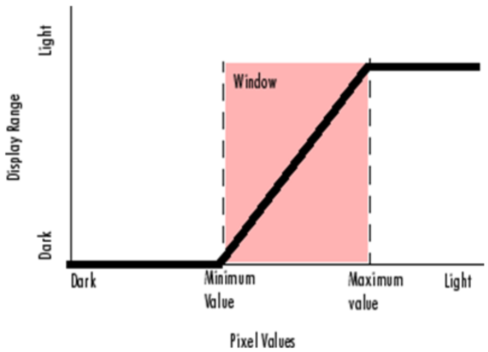


Figure 3. Relationship of pixel values to display range.

From Figure 3, adjust contrast tool achieves contrast stretching by adjusting the CLim property of the axes object that contains the image. The CLim property organizes the mapping of image pixel values to display intensities. According to the data type, Image Viewer sets the CLim property to display the range by default. For instance, the range of an image class is uint8 from 0 to 255. Create a window over the range that defines which pixels in the image map to the black in the display range by shrinking the range from the bottom up. While adjusting the contrast, pixel values may change so there is a possibility to occurring salt and pepper noise[10,21].

3.2.2 Median Filter

Commonly the salt and pepper noise may affect the medical scanned image. So median filter is used to remove salt and pepper noise and preserves edges[21].

$$M = [I_{m\_min} + (N/2 - F_n)\, f_n].* C$$

Equation 1. Median filter to remove salt and pepper noise.

Where I_{m_min} - Lower boundary of the median class.
N - Sum of frequencies.
F_n - n number of frequencies with cumulative frequency before the median class.
f_n – n frequencies of the median class.
C - Size of the median class.

This median filter follows the following steps which are denoted below:

- Find out the sum of frequencies and cumulative frequency of image.
- Compute median class.
- Select lower boundary of the median class.
- Find out frequency and size of the median class.

This is a linear interpolation which finds where the actual median would be if you assume that the data are uniformly distributed within the median class. Median filter is an order statistic method is able to remove speckle or salt and pepper noise[10,21]. The noise segregates itself in front of the median and the median never comes near it, while still giving a nice estimate of central tendency.

3.2.3 Stationary Wavelet Transform

After filtering the salt and pepper noise the frequencies of an image may go to out off frequency. So that is called as noises, removed by SWT. SWT is the advanced technique of DWT. DWT suffers a drawback which doesn't have a time-invariant transform. The idea of SWT is slightly different with DWT, called ε-decimated DWT, to define the Stationary Wavelet Transform (SWT). There exist a lot of slightly different ways to handle the Discrete Wavelet Transform. By performing all the different possible decompositions of the original signal and have 2^J different decompositions for a given maximum level J and use the DWT with periodic (per) extension. Let denotes by $\varepsilon_j = 1$ or 0 the choice of odd or even indexed elements at step j. The result of decomposition is labeled by the sequence 0s and 1s: $\varepsilon = \varepsilon_1 ..., \varepsilon_J$. This transform is called the ε-decimated DWT.

Each ε-decimated DWT corresponding to a given ε can be inverted. The idea behind the inverse discrete Stationary Wavelet Transform is to average the inverses obtained for every ε-decimated DWT. This can be done recursively, starting from level J down to level 1. Finally it gives de-noised image. After enhancement of MRI image, the result is taken as input for ASSRG segmentation.

3.3 Detect and Extract Tumor Portion

The enhanced image is utilized for segmentation. Even though the ASSRG is well worked with noise, it needs to de-noise the image for tumor extraction. In ASSRG, center point of the image is taken as a seed point. Once seed point is selected, the region is iteratively grown through computing all unallocated neighboring pixels to the region based on the similarity. Differentiation of the intensity of a pixel's value and region's mean are used to measure the similarity. The pixel with the smallest dissimilarity measured this way is allocated to the region. The process stops when the intensity difference among region and new pixel becomes larger than a certain threshold. The following criteria involved in the ASSRG:

- Seed point should be selected automatically.
- Seed point must have high similarity to its neighbor pixels.
- For a predictable region, at least one seed should be generated to produce the region.
- Seeds of different regions should be disconnected.

The main intention is to create fully automatic segmentation. Many ways are used to select automatic seed point. One of the ways is to find the mean value of an image which is taken as a seed point. Afterward seed point is compared with neighbor pixels which contains high similarity that is added into the regions. Likewise seed points are grow in the image. Comparable regions are added together with the high similarity pixels. In the expected region at least one seed point must be generated to produce the region. Low similarity of seed point is formed as another region that is disconnected from the expected region. Finally similar regions are connected together in order to get segmented image. So the segmented image will be found which shows the presence of tumor. And then the tumor portion would be taken by the morphological operations. Basic operations such as Dilation and Erosion are used for tumor extraction. Dilation operation facilitates to grow up the boundary of the segmented image. Morphological operations for skull stripping is needed as it moreover looks like white tissues accordingly to avoid uncertainty. Initially erosion operation is used which will help to shrink the boundary of the image based on the structuring element. Finally the tumor region could be extracted. If there are some pixel which do not belong to tumor region that are removed with the help of connected components. Extraction of regions by connected components from a binary image is more important for many automated image analysis applications. All the connected components are by the following iterative procedure.

Then connected components are labeled if there are more objects in an image. Hence the properties of the connected components, the solid pixels would be taken for tumor extraction. This solid pixels size should be more than 0.2[3]. Here labeled connected component is fulfilling the constraints that are extracted as a tumor region.

3.4 Calculate Area of the Tumor

The outcome of tumor region is used to calculate the area and number of pixels in the region. Number of tumor cells and area are calculated by using the following formulas:

I (image) = $\sum_{x=0}^{255}\sum_{y=0}^{255}\left(f[0]+f[1]\right)$

Equation 2. Image formation.

Total number of pixels = width * height

Equation 3. Total number of pixels of image.

Where f[0] = black pixel's digit '0', f[1] = white pixel's digit '1'

Number of white pixels (p) = $\sum_{i=0}^{255}\sum_{j=0}^{255}\left(f[1]\right)$

Equation 4. White pixel calculation from binary image.

Where p = number of white pixels (cm^2)[7].

Area of single pixel = (1/96) × (1/96) inch.

Equation 5. Area of single pixel in an image.

Area of the tumor = Area of single pixel × total number of pixel (cm^2)[13].

Equation 6. Area of tumor region.

Basically the binary image contains two pixel types which are black and white as in (1) By the help of equation, (2) Can find the measurement of white pixels. The area of the tumor region can be measured with the Equation (4).

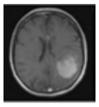
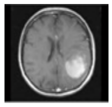
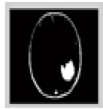
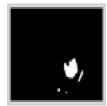
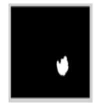
4. Discussion and Evaluation

4.1 Experimental Results

The existing de-noising approach is modified for better segmentation. Table 1 contains input grayscale image, contrast enhanced and de-noise image, the result of region growing segmentation and the morphological operations and Extracted tumor region are respectively. In morphological operation, dilation and erosion are done on segmented image with disk shape structuring element and the size is 6, results are shown in below Table 1.

The Table 1 is described that the result experimented by the improved de-noised approach with segmentation. Many images are also tested with this novel approach. That shows improved de-noising method can work well with more images, some of the results are shown in Table 2. Below Table 2 contains input image, segmented image and extracted tumor region image.

Table 1. Results of improved de-noise approach with segmentation

Description	Input image	Contrast Adjusted and denoise image	ASSRG segmented Image	Morphological operations	Extracted Tumor region
Resultant image					

In Tables 1 and 2, extracted tumor regions are taken to estimate the tumor region and the number of pixels. These results are revealed in Table 3.

Table 2. Results of improved novel approach for various images

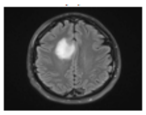
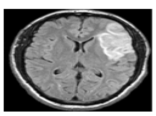
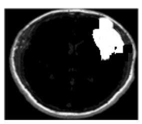
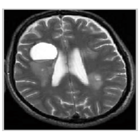
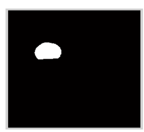
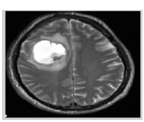
Images	Input image	Segmented image	Extracted tumor region
Image2			
Image3			
Image4			
Image5			

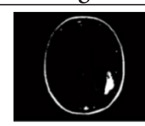
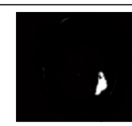
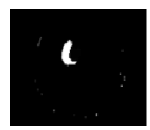
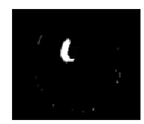
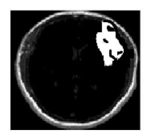
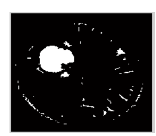
Table 3. Number of pixels and area of the tumor region

Image	Number of cells in a tumor region	Area of the tumor region (cm^2)
Image1	1436	2.558160
Image2	1458	1.582031
Image3	2458	3.582031
Image4	1549	1.680773
Image5	3506	3.804253

4.2 Evaluation

This work focus is main attention to extraction of the tumor in the brain MRI image. So the de-noising technique is needed to enhance the image for extracting the exact tumor region from the MRI brain tumor image. The existing novel method is used to scrutinize noise. It is well worked for de-noising the image alone. When it is used for segmentation there is a problem that is missing many tumor regions' pixel. The exact tumor region couldn't be extracted. The result of novel method is shown in below Table 4.

Table 4. Results for segmentation using existing novel de-noising approach

Images	Segmented Image using existing novel denoising method	Extracted Tumor region
Image1		
Image2		
Image3		
Image4		
Image5		

From Table 4, results are clearly shown that the novel approach de-noising methods is not properly worked with ASSRG segmented image. So the novel approach is modified to work in favor of the ASSRG segmentation. The result of modified novel approach is shown in Table 2.

4.3 Image Quality Parameters for Analysis

Image Quality Measurement (IQM) is essential in the development of image processing algorithms such as de-blurring, de-noising etc. as it can be used to estimate their performances in terms of quality of processed image. 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), Mean Square Error (MSE), Peak Mean Square Error (PSNR), Structural Content (SC) and Normalized Cross Correlation (NCC) are examples IQM measures[7].

4.3.1 Mean Squared Error (MSE)

The MSE is used to find the average squared difference between input and de-noised image. The error is the amount by which the value obscure by the estimator differs from the quantity to be estimated. It is expressed as:

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

Equation 7. Mean Squared Error.

Where x is the original image and x' is the de-noised image, M and N is number of rows and columns of the image. If MSE is 0 it denotes the lowest error rate which means it's a good result. Otherwise the result needs to enhance.

4.3.2 Peak Signal-To-Noise Ratio (PSNR)

The PSNR is the ratio between the maximum possible power of a signal and the power of corrupting noise that involves the consistency of its representation. PSNR is the assessment of the reconstructed image quality. The PSNR represents a measure of the peak value of the error and which is directly proportional to the MSE.

This means that a high value of the PSNR provides a higher image quality likewise; 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:

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

Equation 8. Peak Signal to Noise Ratio.

Where n is maximum possible value that can be attained by the image signal and MSE is Mean Square Error.

4.3.3 Normalized Cross Correlation (NK/NCC)

NCC is a measure of resemblance of two images as a function of a time-interval applied to any one of them. It is co-relational based quality measure between the pixels of original and reconstructed image. Normally NCC lies between 0 to1, very near to or one is the best. This is also known as a sliding inner-product or sliding dot product. It is expressed as:

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

Equation 9. Normalized Cross Correlation.

Where x is the ground truth image and x' is the tumor extracted image, M, N are number of rows and columns of an image.

4.3.4 Normalized Absolute Error (NAE)

NAE is the difference between the inferred or measured value of a quantity and its actual value. The large the value of NAE means that image is poor quality. It is articulated as:

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

Equation 10. Normalized Absolute Error.

Where M and N is number of rows and columns of an image, x is the ground truth image and x' is the tumor extracted image.

4.3.5 Structural Content (SC)

SC is actual distinguish between original and de-noised image. It is correlation based quality metrics which is generally looks at correlation features among the pixels of original and reconstructed image. In general, SC lies between 0 to1, very near to or one is the best. SC is represented as:

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

Equation 11. Structural Content.

Where x is the ground truth image and x' is the tumor extracted image, M and N - rows and columns of an image.

These measurements are used for measure the dissimilarity between input image and de-noised image[10]. The quality should be measured for the improved de-noising method and existing de-noising method. Each image can be compared with the original input image and existing de-noising method. That statistical result is shown in Table 5.

Table 5. Results for segmentation using existing novel de-noising approach

IQM/ Images	Image1	Image2	Image3	Image4
MSE	44.0533	109.4396	70.6554	77.9763
PSNR (db)	87.7774	73.4776	68.2471	67.2612
NCC	1.0347	1.0040	1.0070	1.0259
AD	-1.0686	0.1630	-0.1806	-1.4602
SC	0.9181	0.9689	0.9712	0.9372
MD	58	45	36	33
NAE	0.0213	0.0872	0.0929	0.1138

From the above Table 5, the values of SC, NCC, AD and NAE are lies among 0 to 1. Here SC and NCC values near 1 is shows the better result. MSE values are should be low is for better result. PSNR value should be high that denotes better from loss. The below Figure 4 is a graphical representation of the statistical IQM results of Table 5.

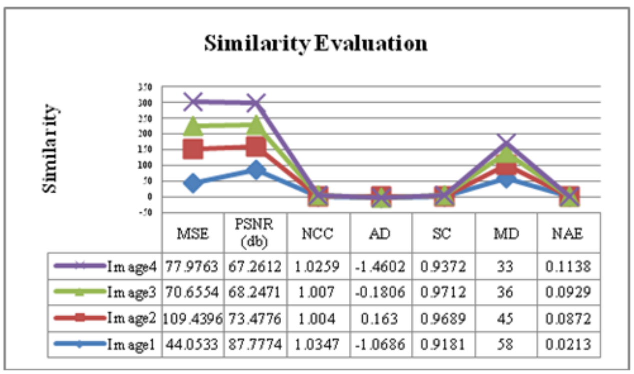


Figure 4. IQM for improved denoising method with ASSRG segmentation.

The quality of images can also be measured by contrast and noisiness. The existing de-noised image is not well worked with the ASSRG segmentation and the statistical measurement is clearly shown below Table 6.

Figure 5 is a graphical representation that shows the quality measurements of all the quality parameters shown below:

Improved de-noising method results are compared with the original input image. Comparison of Tables 5 and 6 shows the changes of the quality in the improved de-noise image which is better than the existing novel approach. Table 5 shows that there is a better improvement in the image quality than that Table 6. And this enhanced denoising novel approach is giving the fruitful results that are proved statistically in Table 5 and experimentally in Table 2.

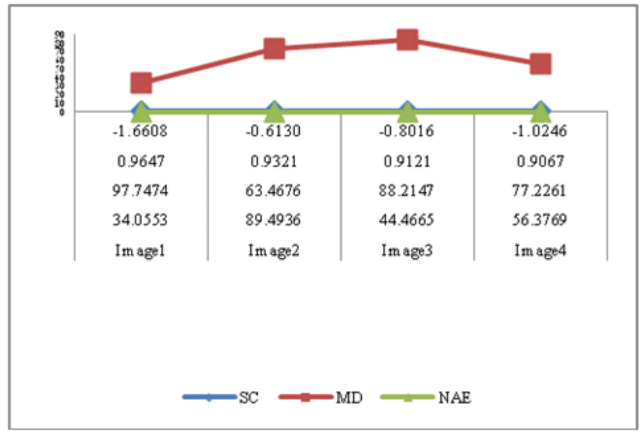


Figure 5. IQM for existing de-noising method with ASSRG segmentation.

Table 6. Quality measurements of various MRI brain images using existing de-noising methods

IQM/ Images	Image1	Image2	Image3	Image4
MSE	34.0553	89.4936	44.4665	56.3769
PSNR (db)	97.7474	63.4676	88.2147	77.2261
NCC	0.9647	0.9321	0.9121	0.9067
AD	-1. 6608	-0. 6130	-0. 8016	-1. 0246
SC	0.8591	0.9869	0.9178	0.9564
MD	34	73	84	56
NAE	0.0313	0.0983	0.0857	0.0831

5. Conclusion

Thus it can be inferred that the Automatic Single Seed Region Growing method is the well known segmentation method for noisy image and has proved its soundness in many applications. This paper has presented a novel approach for improved denoising method which is well worked with the segmentation. This segmented result was fit for extracting tumor region alone using MRI brain tumor images. The proposed novel approach of improved de-noising method was compared with the existing de-noising method. And the results were applied with IQM to find out the dissimilarity between original and de-noise images. The experimental results demonstrate the effectiveness of the proposed work. In future, the tumor region is taken for classification of tumor types such as benign and malignant.

6. References

1. Preetha MMSJ, Suresh LP, Bosco MJ. Image segmentation using seeded region growing. International Conference on Computing, Electronics and Electrical Technologies [ICCEET]; Kumaracoil. 2012 Mar 21-22. p. 576–83.
2. Kaur J, Kaur R. Image de-noising for speckle noise reduction in ultrasound images using DWT technique. IJAIEM. 2013 Jun; 2(6):384–96.
3. Anithadevi D, Perumal K. Brain tumor extraction based on segmentation. IJRITCC. 2014; 2(9):2682–9.
4. Wu J, Poehlman S, Noseworthy MD, Kamath MV. Texture feature based automated seeded region growing in abdominal MRI segmentation. International Conference on Biomedical Science and Engineering. BMEI '09. 2009; 2(1):263–7.
5. Anithadevi D, Perumal K. Generic evaluation of automatic segmentation with seed selection. National Conference Contemporary Developments in Information and Communication Technologies; Madurai. 2014. p. 14–24.
6. Janani S, Marisuganya R, Nivedha R. MRI image segmentation using Stationary Wavelet Transform and FCM algorithm. International Conference on Innovations in Intelligent Instrumentation, Optimization and Signal Processing. ICIIIOSP; 2013. p. 1–4.
7. Kaur R, Kaur R. Remove the noise from medical images using Discrete Wavelet Transform. IJEAT. 2013; 3(2):1611–4.
8. Mirajkar Pradnya P, Ruikar SD. Image fusion based on Stationary Wavelet Transform. International Journal of Advanced Engineering Research and Studies. 2013 Jul-Sep; 2(4):99–101.
9. Soundarya K. Video de-noising based on Stationary Wavelet Transform and Center Weighted Median Filter. International Journal of Information Technology BVICAM. 2014 Jan-Jun; 6(1):722–6.
10. Anithadevi D, Perumal K. Novel approach for noise removal of brain tumor MRI images. JBEMi. 2015; 2(3):1–14.
11. Zhu R, Wang Y. Application of improved median filter on image processing. Journal of Computers. 2012; 7(4):838–41.
12. Prema C, Vinothini AG, Nivetha P, Sahaya Suji A. Dual tree wavelet based brain segmentation and tumor extraction using morphological operation. International Journal of Engineering Research and Technology. 2013 Apr; 2(4):2716–9.
13. Kaur K, Singh G, Singla A. Research on spatial filters and homomorphic filtering methods. JGRCS. 2012; 3(11):1–4.
14. Raj VNP, Venkateswarlu T. De-noising of medical images using image fusion techniques. International Journal of Signal and Image Processing. 2012 Aug; 3(4):65–84.
15. Al Jumah A. De-noising of an image using discrete stationary wavelet transform and various thresholding techniques. Journal of Signal and Information Processing. 2013 Feb; 4(1):33–41.
16. Patil RC, Bhalchandra AS. Brain tumor extraction from MRI images using MATLAB. International Journal of Electronics, Communication and Soft Computing Science and Engineering. 2011; 2(1):1–4.
17. Kowar MK, Yadav S. Brain tumor detction and segmentation using histogram thresholding. IJEAT. 2012 Apr; 1(4):16–20.
18. Sasi Varnan C, Jagan A, Kaur J, Jyoti D, Rao DS. Image quality assessment techniques in spatial domain. IJCST. 2011 Sep; (3):177−-84.
19. Sasirekha N, Kashwan KR. Improved segmentation of MRI brain images by de-noising and contrast enhancement. Indian Journal of Science and Technology. 2015 Sep; 2(22):1–7.
20. Prasad S, Ganesan N. An image sharpening method by suppressing the noise. International Journal of Computer Applications. 2012; 51(16):14–22.
21. Varade MRR, Dhotre MR, Pahurkar AB. A survey on various median filtering techniques for removal of impulse noise from digital images. IJARCET. 2013 Feb; 2(2):606–9.