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# Segmentation of Tumor in MRI Brain Images using Morphological Operators and Non-Local Means Filter

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**Abstract:** ***Brain Tumor is the abnormal development of tissues in the brain. According to survey report Times of India, 2019 around 5, 00,000 people are diagnosed with brain tumor in India. Among 5, 00,000 people 20 percent are children. Magnetic resonance image (MRI) used for clinical analysis of human body are sensitive to redundant Rician noise. Rician is the type of noise added during the acquisition of MRI. The removal of noise variance can be performed by constructing many filters. Among those filters, non-local means filter is used for denoising the Rician noise. In this project simulated MRI data and real time clinical data of T1, T2 and Proton Density weighted MRI images are de-noised and the performance metrics is analyzed using PSNR (Peak Signal to Noise Ratio) and SSIM (Structural Similarity Index Metric). The de-noised image is then subjected to thresholding and morphological operators and the tumor region is segmented.***

***Keywords: Non-local means filter, Performance metrics, Rician noise, Segmentation.***

## I. INTRODUCTION

MRI (Magnetic Resonance Imaging) is a powerful imaging technique used for diagnosing various diseases in human body. Among other imaging modalities like the X-ray, CT etc., MRI is a major tool for visual representation of the human body because of its accurate representation and functional characterization of the internal human body. Magnetic resonance imaging (MRI) of the human body are produced by powerful magnetic field, radio waves and a computer to produce detailed structure of the inside of our body. It will be used to help diagnose variety of conditions within the chest, abdomen and pelvis. MRI does not involve invasive radiation (x-rays). Detailed MR images help doctors to examine and detect disease.

The images can be viewed on a monitor. They can also be electronically sent, printed or copied to a CD (compact disk0, or uploaded to cloud. The traditional MRI unit consists of a large cylinder-shaped tube surrounded by a circular magnet. The patient will lie on a table that slides into the center of the magnet. In some MRI units the magnets do not completely.

Surround you. Even though the tremendous improvement of resolution, acquisition speed and signal to noise ratio in MRI, the quality of the MR images are still affected by noises. Noises may be eddy current noise or the noise due to the magnetic Susceptibilities between the tissues. Thus, removing the noise component in the MR images is necessary to reduce such noises for improving the validity and the accuracy of the human body.

### *A. Rician noise*

The noise in the MRI are considered in rician distribution. Rician noise is a type of disturbances or noise added during the acquisition process of the magnitude MRI image, which makes the diagnosis difficult. Rician distribution is signal dependent and it is difficult to separate noise from the signal. It is very critical especially images with low quality, or with low Signal to Noise Ratio. It adds signal dependent bias to the data that lowers the contrast of the image, as well. Noise level are measured by means of standard deviation of the pixel values in that region. The data should be distributed with rician noise so as to add the noise to an image. As it is mainly due to the thermal noise the rician noise appears to be in white, additive and follows same as. Though all the information is contained in complex data, it should be transformed to magnitude data, because both the anatomical and physiological information of the MRI can be processed in an efficient way. The transformation of MR data changes the Gaussian distribution to rician distribution. The PDF of rician noise is given as (1),

$$p(M|A,\sigma) = \frac{M}{\sigma^2} exp\left(-\frac{M^2+A^2}{2\sigma^2}\right) I_0\left(\frac{AM}{\sigma^2}\right) u(M) \quad (1)$$

M is the signal magnitude

A is the amplitude of signal without noise

Io represents the modified Bessel function,

u(M) represents unit-step function

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*B. Brain tumors*

Brain tumor occurs due to the abnormal growth of the cell in the brain. The world health organization (WHO) has given a statistic that around 4 lakh people are affected by brain tumor in the world. The brain tumor can be classified into two types malignant (cancerous) tumors and the benign (non-cancerous) tumor.

The malignant tumors may be of two types which is the primary tumors and the secondary tumors. The primary tumors are one which start within the brain and the secondary tumors are the one which spread from elsewhere, also known as brain metastasis. MRI plays a major role in identifying the tumor location by segmentation and to treat the patients accordingly.

## II.LITERATURE SURVEY

Kala et al (2018) have done a study on adaptive hexagonal fuzzy hybrid filter and stated that it has a netter restoration than the existing system. It has the improvement in mean for T1, T2 and proton density weighted images than the fuzzy hybrid filter with trapezoidal membership. This method has the capability in reducing the noise in the efficient manner. They also consider the correlated noise for the removal.

Siyu Lu et al. (2019) has proved that the non-local means filter has the better restoration performance than the existing method. They followed improved pixel selection based algorithm which reduces the usage of useless pixels the principle behind this is the similarity between the neighborhood median values that are not sensitive to noise. They have also analyzed the performance metrics like peak signal to noise ratio (PSNR) and other quality methods.

Shital S. Agrawal and Prof. Dr. S. R. Gupta (2014) has proposed various algorithm for brain tumor detection. Edge detection is the important parameter in segmentation of tumor in MRI images. They developed an algorithm based on the symmetric character of the brain and thus segmenting it based on the symmetry. They proved that their algorithm is convenient and reliable.

Mohan (2014) in this thesis he proposed and analyze the de-noised MR image using neutrosophic set theory mainly for structure preservation. He analyzed three different denoising methods like neutrosophic set approach of median filtering, wiener filtering and non-local means filtering. The performance metrics are evaluated based on the noise removal and the structural preservation using both clinical dataset and simulated dataset.

Vikrant bhateja (2013) developed non-local means filter algorithm for rician noise removal in MRI images. It works on the weighted average of all the pixels based on the similarity of the windows based on the Euclidean distance for MRI restoration.

Xia Lan et al (2010) proposed the method of adaptive non local means filter for MRI noise removal. This algorithm works on the principle of region homogeneity and the window sixe for de-nosing varies adaptively. They proved that the adaptive non-local means filter is better the non-local means filter.

Manjón, et al, (2008) have done a novel study on the random noise removal in MRI images by the parameter filter called non-local means filter. For this study they have conducted experiments for finding the optimum parameter for the different noise levels. This has been used to Signal to Noise Ratio of the MRI images.

Aja Fernandez (2007) proposed a method for rician noise removal in MRI images. They have also derived the linear minimum mean square error estimator for the rician noise distribution. A recursive version of LMMSE shows a good performance of noise filtering and feature preservation.

Mark Schmidt et al. (2005) developed a segmentation tool based on the alignment. They used aligned spatial templates to gather anatomical information about the brain. They have also analyzed the feature in determining the classification of supervised pixel.

## III. EXISTING METHODS

One of the traditional ways to remove the noise from the dataset is the filtering approach the filter can be classified into linear and non-linear filter.

*A. Median filter*

Most common non-linear filtering technique used to remove the noise from the images. The main algorithm of median filter is that it goes entry by entry throughout the signal and it replaces each pixel value in an entry by the median value of the neighboring windows. The median value can be obtained by using efficient sorting algorithm. The median filter is also called as the sliding window filter that it replaces the center value of each window with the median value. One of the major disadvantages is the computational burden of sorting algorithm even though the efficient algorithm is used.

*B. Wiener filter*

It is a linear time invariant filter which produces the estimate of a desired random process of a noisy image. It minimizes the mean square error between the noisy image and the random process.

The wiener filter can be defined as (2),

$$G(u,v) = \frac{H*(u,v)P_s(u,v)}{|H(u,v)|^2 P_s(u,v) + P_n(u,v)} \qquad (2)$$

H (u, v) is the Fourier transform of spread function,

$P_s(u,v)$ is the signal process power spectrum,

$P_n(u,v)$ is the of the noise process power spectrum,

## III. MATERIALS AND METHODS

*A. Non local means filter*

Non-local means filter mainly depends on the pixels in local neighbor in a small neighborhood in order to reduce the noise. It exploits the information redundancy of an image. The small structures are considered as noise and they are removed, the large structures are preserved. It helps to remove the spatially varying noise levels.

The main algorithm of NLM filter is the calculation of weighted average of all the pixels over a selected window based on the similarity of the pixels and replacing the pixel value of the similar patches with the weighted average. In a given noisy image $u = \{u(i) i \in I\}$

$$NL[u](i) = \sum_{j \in 1} w(i,j)u(j)$$

$NL[u](i)$ is the weighted average of all pixels in the image, where w (i, j) is the normalized weights which is computed based on the similarity between the pixel i and j, which follows the condition $0 \le w(i,j) \le 1$and $\sum_j w(i,j) = 1$. The similarity depends upon the similarity of the intensity of the gray level vectors $u(N_i)$ and $u(N_j)$. The decrease in the function of Euclidean distance determines the rate of similarity of the pixels. The Euclidean distance gives rise to the following equality (4),

$$E\left\|u(N_i) - u(N_j)\right\|^2 = \left\| \left|u(N_i) - u(N_j)\right|^2_{2,a} \right\| + 2a^2 \quad (4)$$

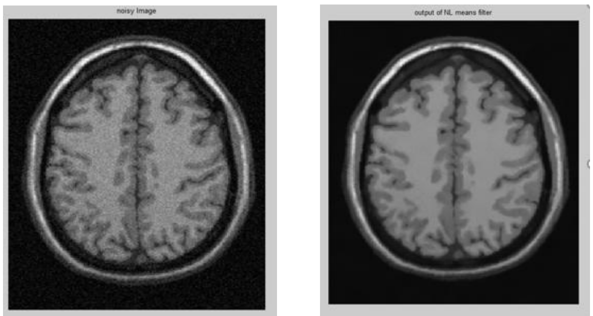
The weights can be calculated as,

$$w(i,j) = \frac{1}{z(i)} e^{\frac{\left\| |u(N_i) - u(N_j)|^2_{2,a} \right\|}{h^2}} \quad (5)$$

Where z(i) is the normalization constant (6),

$$Z(i) = \sum_j e^{\frac{\left\| |u(N_i) - u(N_j)|^2_{2,a} \right\|}{h^2}} \quad (6)$$

h is the filtering parameter; it controls the decay of weight as the Euclidean distance.

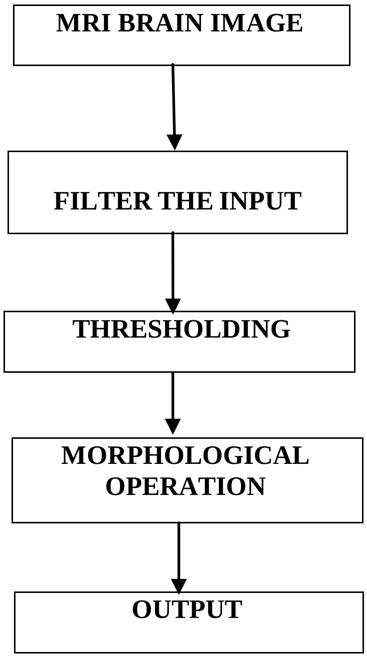



(i) (ii)

**Fig 1. (i) MRI image with noise (ii) Denoised image using NLM filter**

*B. Segmentation of tumor*

The main objective of image segmentation is to represent or to partition the image for useful analysis and more meaningful. It is used to locate the boundaries and edges of the image. Tumor segmentation is process of segregating the tumor from the MRI image used for clinical analysis and treatment. It is one of the critical tasks in medical imaging techniques. Normally in MRI images with tumor, the regions where the tumor present are more condensed then all other surrounding area. The pixels in the tumor regions are brighter than the other pixels in image. The basic concept is to identify the dense clusters of pixels that are brighter than the surrounding areas. Several researches have been carried out for segmentation. Among those techniques the proposed work is based on the segmentation using thresholding followed by the morphological operation.




(3)

**Fig 2. Flowchart of segmentation process**

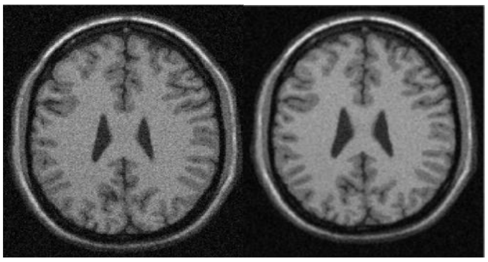
One of the simplest techniques of segmentation process is the thresholding technique. The first step is to convert the digital image into the binary image. The converted binary image is then undergone through non-local means filtering and the rician noise that corrupts the MR image is denoised. The selection of thresholding value is main concept. Whole image is then subjected to the thresholding process. The obtained threshold value is compared with all the pixels through the image and the pixel values that are greater than the threshold value are considered as foreground and set into white and if the pixel value is less than the threshold value then it is considered as the background and set into black. This is the basic logic beyond effective segmentation process. This segmentation process showed the better accuracy than other segmentation process.

*C. Modalities of MRI used as dataset*

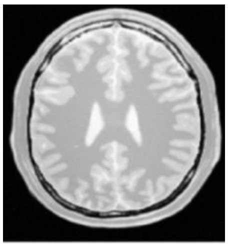
In MRI a uniform magnetic field is applied to align the protons which are aligned in random manner within the tissue nuclei. This way of alignment is disrupted by the application of external radio frequency. The nuclei will return to their alignment by various relaxation technique and during the relaxation the RF energy is emitted. The sequence of RF pulses is varied and different images are obtained. The time between the successive RF pulses are called as the repetition time (TR). The time between the application of RF pulse and reception of echo signal is called as the Echo time (TE). Modalities can be classifies based on the TR and TE of RF pulse. The mar classification of modalities of MRI image are T1 weighted, T2 weighted, proton density (PD) weighted.

T1 weighted MR images are used to determine the contrast and the brightness of the image. T1 weighted images can be produced by using gadolinium (Gad). Gad is the paramagnetic non-toxic substance used for contrast enhancement. T1 weighted images are produced by short TR and TE times.

Fat regions will have the short T1 values and it appears dark. Water and cerebrospinal fluid (CSF) have long T1 values. T2 is called as the transverse relaxation time, the time at which the excited protons go out of phase. T2 weighted images are produced by long TR and TE times. Cerebrospinal fluid is dark in T1 weighted image and brighter in T2 weighted images. The PD weighted images give the number of protons per unit volume. To make image PD weighted the T1 and T2 are made to be in active. The signal intensity depends upon the number of protons if the number protons are more it has high intensity and if there is less protons it will have low intensity of signal. They are created by long TR and short TE values. It produces the difference between the gray and white matter in the brain.



(i) (ii)



(III)

**Fig 3. T1 weighted (i), T2 weighted (ii), PD weighted (iii)**

## IV. RESULTS AND ANALYSIS

*A. Peak signal to noise ratio (PSNR)*

It is used to calculate the maximum power of the original signal to the power of the signal corrupted with noise. It is mainly calculated from the mean square error (MSE).

$$PSNR = 10.\log_{10}\frac{MAX_I^2}{MSE} \quad (7)$$

PSNR are often represented in decibel. Higher the value of the PSNR higher is the quality of the image.

*B. Structural similarity index metric(SSIM)*

It provides an analysis as, how the denoised and the original images are similar. The similarity here represents the information preservation. The value ranges from 0 to 1. The image quality is computed with the initial uncompressed image and the distortion free image as reference.

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)} \quad (8)$$

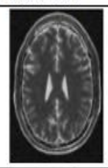
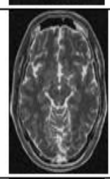
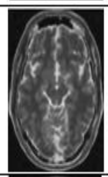
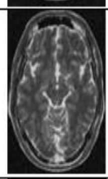
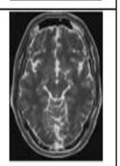
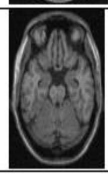
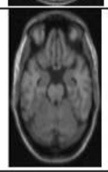
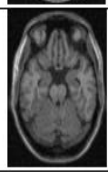
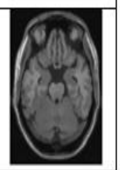
$\mu_x$ and $\mu_y$ are the mean of x and y,

$\sigma_x$ and $\sigma_y$ are the standard deviation of x and y,

Table 1. Performance Analysis

| Image | Parameters | WEINER FILTER | MEDIAN FILTER | NLM FILTER |
|---|---|---|---|---|
| **SET I** | **PSNR** | 24.445699 | 23.592721 | 30.416247 |
| | **SSIM** | 0.557241 | 0.575227 | 0.821177 |
| **SET II** | **PSNR** | 24.168555 | 27.002113 | 30.864804 |
| | **SSIM** | 0.609017 | 0.668470 | 0.848565 |
| **SET III** | **PSNR** | 27.157276 | 23.502564 | 30.115595 |
| | **SSIM** | 0.632355 | 0.638181 | 0.788809 |

**Table 2. comparison of wiener, median and NLM filter**

| Sl.no | NOISY IMAGE | WIENER FILTER | MEDIAN FILTER | NLM FILTER |
|---|---|---|---|---|
| SET I |  |  |  |  |
| SET II |  |  |  |  |
| SET III |  |  |  |  |

On comparing the performance metrics like PSNR and SSIM, the value of PSNR is higher for NLM filter this shows that the quality of the image is good in NLM filter, analysis of SSIM value shows that the information and the edges are preserved more in NLM filter than the most commonly used wiener and median filter.

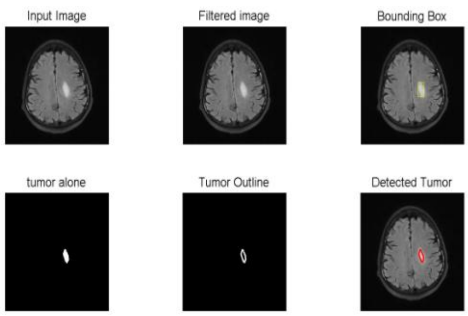



**Fig 4. Segmentation of tumor**

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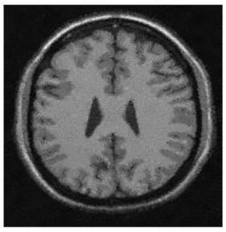
The above figure shows the segmentation output of the tumor. First step is to get the denoised image and the next process is to threshold the whole image after finding the threshold value, the segmentation is carried out using **morphological process.**

Input image



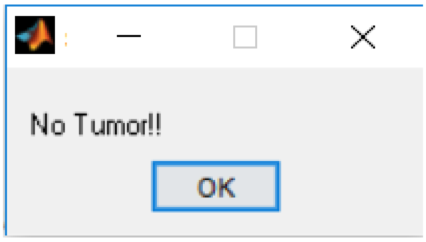



**Fig 5. Segmentation Result Without Tumor**

## V. CONCLUSION AND FUTURE SCOPE

In this paper de-noising of MR brain image by non-local means filter and segmentation of brain tumor using morphological operation is performed. The performance metrics like PSNR, SSIM and MSE are analyzed for the de-noised image. The NLM filter showed better performance than the most commonly used median and wiener filter for T1, T2 and PD weighted MR images for various noise levels. The analysis of SSIM values shows that the edges are preserved more in NLM filter than wiener and median filter. The de-noised MR image is segmented using thresholding and morphological operators for various clinical datasets and the tumor location was identified.

In future the classification algorithm may be developed for classifying the tumors into benign and malignant and to further classify the four grades of malignant tumor as Meningioma, Glioma, Astrocytoma and Metastasis.

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