# Hybrid Method for MRI Image Denoising

Deepika
Research Scholar
deeppiika@gmail.com
Janayak Choudhary devilal Memorial Collage of Engg
Sirsa, Haryana

Aman Paul
Assistant Professor
Amanpaul.thind26@gmail.com
Janayak Choudhary devilal Memorial Collage of Engg
Sirsa, Haryana

**Abstract -** The process in which data required for the generation of images is sampled in the spatial frequency domain in direct manner is known as Magnetic resonance imaging (MRI). In order to sample the 3D spatial frequency volume, several models are used. One of these paradigms has become the route of various 3D radial spokes which is analogous to a kooshball. The main advantage of this phenomenon is the presence of important undersampling. This undersampling can be executed devoid of aliasing artifacts in comparison with the minimal sampling density recommended by the Shannon-Nyquist sampling theorem. To improve efficiency of NLM filter, the PNLM filter is designed in this research work. The PNLM filter is further improved in this work using GLCM algorithm. The NLM, PNLM and proposed methods are implemented in MATLAB. It is analyzed that proposed method performs well in terms of PSNR, MSE and other parameters are compared to NLM and PNLM.

***Keywords*** *- MRI, Image denoising, NLM, PNLM*

## I. INTRODUCTION

The process which is used for image enhancement or for the extraction of some important features by executing some operations on it is known as image processing. The image processing is a kind of signal dispensation. In this approach, pictures or video frames are applied as input. The output may be in the form of picture or some features related to that picture [1]. The image processing is of two types i.e. analog image processing and digital image processing. When digital images are manipulated by means of computers, then this process is called digital image processing. An image is commonly identified as the distinct demonstration of light brightness inside the space. An incessant vision within the space and light brightness develops a specific view. The space and light brightness aspects are transformed into distinct values with the help of image digitization. The distinct versions of intensity generate gray values [2]. The picture elements also called pixels describe the distinct version of location. Therefore, a gray value related to the light intensity is produced for every pixel of a picture. A real image can be defined correctly by providing sufficient pixels and gray scale values using image digitization. The process in which data required for the generation of images is sampled in the spatial frequency domain in direct manner is known as Magnetic resonance imaging (MRI). In order to sample the 3D spatial frequency volume, several models are used. One of these paradigms has become the route of various 3D radial spokes which is analogous to a kooshball. The main advantage of this phenomenon is the presence of important undersampling [3]. This undersampling can be executed devoid of aliasing artifacts in comparison with the minimal sampling density recommended by the Shannon-Nyquist sampling theorem. As compared to all the other earlier medical modalities, the MRI approach has proved most effectual and the minimal risky for patients. Mainly the soft tissues of brain and muscles can be sighted in accurate manner using MRI [4]. With the help of MRI, a number of unusual states such as cancer, internal damages, sarcoma etc. can be diagnosed through scanning. It is considered as non-invasive approach as it does not need ionizing radiation. The MRI technique provides excellent contrast between the usual and unhealthy tissues. The procedure of taking MRI image primarily includes the placement of body on the table for scanning. Then, the body slides into a machine tunnel. Some patients also suffer from claustrophobia. Therefore, these days, machines having larger openings are introduced as well [5]. The full images of a body organ to be diagnosed are produced by MRI with the help of natural magnetic properties of the body. In view of the fact that, the hydrogen nucleus has great quantity of water and fat, it can be utilized for imaging purposes. All the protons' axes line up when the body is placed in a strong magnetic field akin to MRI. These days scanning techniques are used in numerous applications [6]. These techniques improve the spatial resolution, SNR and the acquisition speed. But, noise in attainment still influences the analytic and visual quality of MR images during analysis. The MRI images encompass different types of noises such as eddy currents, artifacts, magnetic vulnerabilities and a lot more. Image denoising can be described as a procedure which is used for the removal of noise from a picture. The noise corrupts all the features of a picture during the acquisition procedure or transmission. The image denoising process maintains the quality of a picture. This procedure is the sub branch of digital image processing. In the medical field, timely recognition of disease is necessary [7]. Non Local means (NLM) filter is introduced by Buades. For removing noise form an image, different types of denoising technique has been utilized so far. In these techniques, local pixels are considered within a small neighbor [19]. The small formations are considered as noise and eliminated from the picture.

## II. LITERATURE REVIEW

**JannathFirthouse.P, et.al (2016)** studied that the original intensity of the real image caused no effect on pixel value as noise occurred due to error. Different noises affected the Medical images on the basis of device as the process of transmission and acquisition was done through it [8]. They experienced a contourlet domain for putrefaction of input images in order to denoise Gaussian noises and Speckle noises in the MRI images for this study. In order to preserve the edges and contours, the above mentioned method was utilized. In this study, threshold techniques such as Bayes Shrink, Neigh Shrink, and Block Shirnk etc were implemented after decomposition procedure. With the help of these methods, the noise effects were minimized at the greater level. Therefore, to ensure that enhancement had been achieved by proposed method, different parametric values were computed.

**FarhaFatina Wahid, et.al (2017)** implemented the local fuzzy filter and the basic Non Local Means filter (NLM) [9]. In this study, the Non Subsampled Contourlet Transform (NSCT) approach was also utilized for the fusion of two approaches in the change image. This was done for the denoising a suite of MRI images tainted with additive noise. A number of experiments were performed to evaluate the performance of proposed approach. The attained outcomes concluded the efficiency of the proposed technique in comparison with other methods.

**A.G. Rudnitskii, et.al (2017)** stated that the medical diagnosis was performed through an emerging technology of noninvasive called Magnetic Resonance Imaging (MRI). Low signal to noise ratio (SNR) and contrast to noise ratio (CNR) were the demerits of this method [10]. Some other process such as segmentation, reconstruction and registration were considered for the process of image analysis. Therefore, noise reduction was considered as the pre-processing task before image analysis in MR images. The sufficient understanding for complex objects had been provided by the two dimensional (2D) imaging. Therefore, the demonstration of numerous real objects in 3D computer was essential. In this study, the denoising and segmentation techniques were presented for the development of 3D MRI image on the basis of fractal and morphological approaches.

**R. Sujitha, et.al (2017)** studied that based on wavelet based image denoising techniques, different techniques had been proposed so far [11]. In the process of medical diagnosis, this proposed approach had been utilized. The enhancement in the quality and clinical parameter of an image due to denoising of these images was also used in the research area. In this study, a wavelet-based thresholding scheme was proposed for image denoising and noise removal from MRI images. For analyzing the performance level of proposed approach, some parametric values were computed.

**Hanafy M. Ali, et.al (2017)** proposed a new technique in which a median filter algorithm was modified [12]. In the MRI image, different types of noises were added. In order to eliminate the additive noises from the MRI images, several filters were used. In order to compare the performance and for the evaluation of filters, the noise density was added to the MRI image. Several experiments were performed on the proposed method for evaluating the performance of these filters in comparison with others methods according to the Peak Signal-to-Noise Ratio (PSNR) and so on.

**DongshengJianga, et.al (2018)** proposed a number of methods to recover the noise free images for good performance. The previously proposed methods consumed a lot of time during optimization process. The performance of denoising technique was depended on the estimated noise level parameter. In this study, an enoising MRI Rician noise approach was proposed using a convolutional neural network [13]. Various experiments were performed on the synthetic and real 3D MR information for the evaluation of proposed approach. The attained outcomes showed the usefulness of the proposed method in comparison with other methods in terms of peak signal to noise ratio and the worldwide structure similarity index. Therefore, the proposed method demonstrated good universal appropriateness.

## III. RESEARCH METHODOLOGY

A filtering technique named NLM is used for the de-noising of MRI images. The attributes of MRI images are very much affected by the occurrence of raisin inside the images. The PNLM is the advanced form of NLM algorithm. This algorithm processes the parallel pixels by de-noising the images for a better experience. Moreover, one more algorithm is proposed for having enhanced and reasonable performance is the GLCM algorithm. This approach is utilized to find out the Peak signal-to-Noise Relation (PSNR), Mean Square Error (MSE) and Mean Structural Similarity Index (MSSIM). In this study, GLCM is termed as Grey level Co-occurrence Matrix and also identified as Grey Tone Spatial Dependency Matrix. In this algorithm, the number of rows is equal to the number of columns to the total number of grey levels existing within the images. This algorithm is in the table form and find outs brightness value of different combinations falling in any image. The foremost aim of GLCM is the extraction of statistical surface parameters such as Inverse Difference Moment, Entropy, Angular Second Moment and Correlation. The second order statistical information is one more part of the GLCM algorithm which combines the pixels of the images. This second order statistical information pays attention to the execution of GLCM in VERILOG language. GLCM is also utilized in the assessment procedure of grey co-matrix in the scaled set-up. Let us assume that ‘I’ is the binary image in grey co-matrix scaled format and if ‘I’ is the intensity image which divides the image into eight grey-levels. The numbers of these grey levels are described by the ‘Numlevels’ and gray co-matrix divides the different values through the usage of ‘Graylimits’ parametric values.

**1. PSNR:** It is defined as the ratio of the maximum power of possible signal to the power of corrupting noises. This phenomenon affects the representation of image in huge manner. The logarithmic decibel scale is utilized to depict the PSNR values as dynamic range of different signals lies within the applications.

The Mean Square Value is used to describe the PSNR values, which can be defined as:

$$PSNR = 10.\,log_{10}\left(\frac{MAX_I^2}{MSE}\right)$$

$$= 20.\,log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right)$$

$$= 20.\,log_{10}(MAX_I) - 10.\,log_{10}(MSE)$$

**2. MSE (Mean Square Error):** This parameter is defined as the standard statistical metric values. This parameter is used to measure error between Real Image and Denoise Image. The MSE is computed through the following formula:

$$MSE = \frac{1}{n}\sum_{i=1}^{n} e_i^2$$

Here, n correspond to the samples of model errors *e* calculated as (ei ,i = 1,2,... , n).

**3. RMSE (Root Mean Square Error):** The root value of MSE map over the whole image is computed by RMSE value. The RMSE is computed through the following formula:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n} e_i^2}$$

**4. SSIM (Structural Similarity Index Method):** The alleged quality of digital TV and cinematic images can be forecasted by this method along with the images and videos. This technique provides support to measure resemblance amid two images. This value can be computed in numerous windows of an image. The SSIM value of two windows x and y with similar size of N×N can be calculated by the following formula:

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}$$

Where,

The average of x is represented by $\mu_x$ while $\mu_y$ denotes the average of y. Also, the variance of x is $\sigma_x^2$ and the variance of y $\sigma_y^2$. The covariance of x and y is represented by $\sigma_{xy}$.

**5. MSSIM:** The mean value of SSIM map over the entire image is computed through MSSIM value.

**5. Method Noise:** This parameter calculates the residual from the Denoised image. The method noise depicts the quantity of noise extracted from the image in direct manner.

Method Noise= f(x,y) - n(x,y)

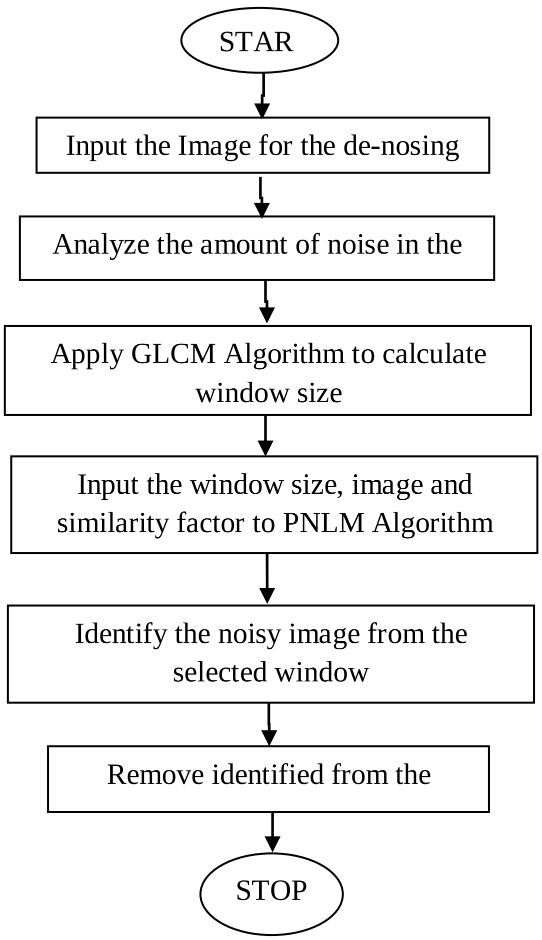


Figure 1: Proposed Flowchart

IV. EXPERIMENTAL RESULTS

The proposed research is implemented in MATLAB and the results are evaluated by comparing the proposed and existing techniques in terms of different parameters.

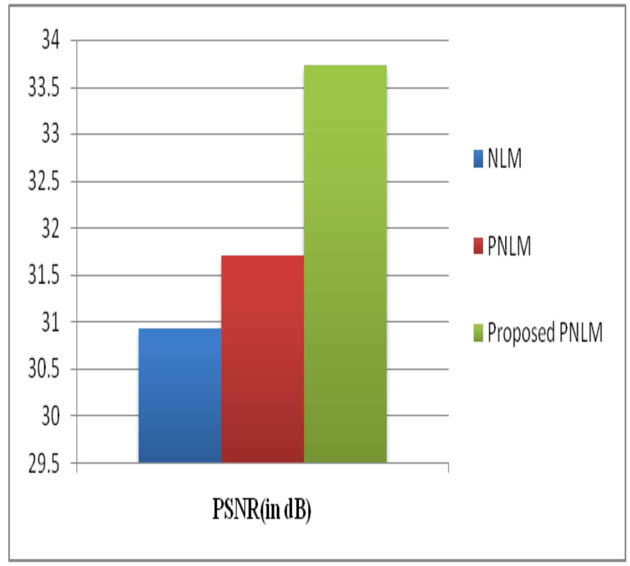


**Figure 2:** PSNR Comparison

The NLM, PNLM and Proposed algorithm are compared in terms of standard PSNR value for the analysis of their performances as depicted by figure 2. It is scrutinized that the proposed algorithm has maximum PSNR value in comparison with NLM and PNLM algorithm.

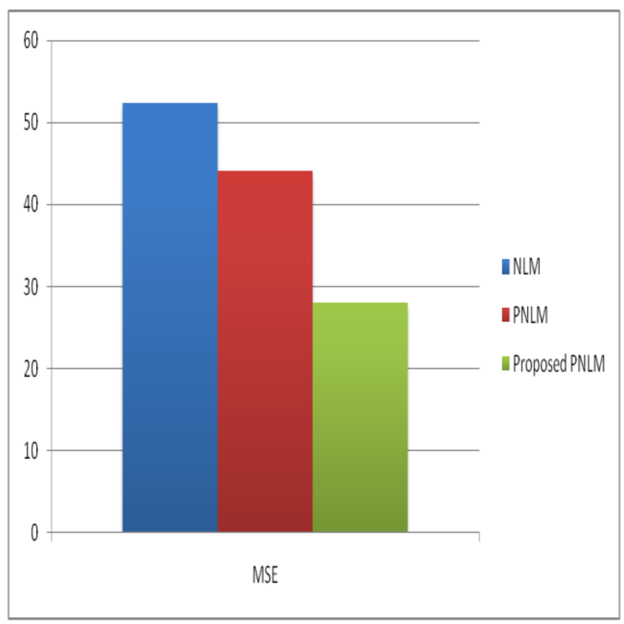


**Figure 3:** MSE Comparisons

The NLM, PNLM and Proposed algorithm are compared in terms of MSE value for the analysis of their performances as depicted by the figure 3. It is scrutinized that the proposed algorithm has least MSE value in comparison with NLM and PNLM algorithm.

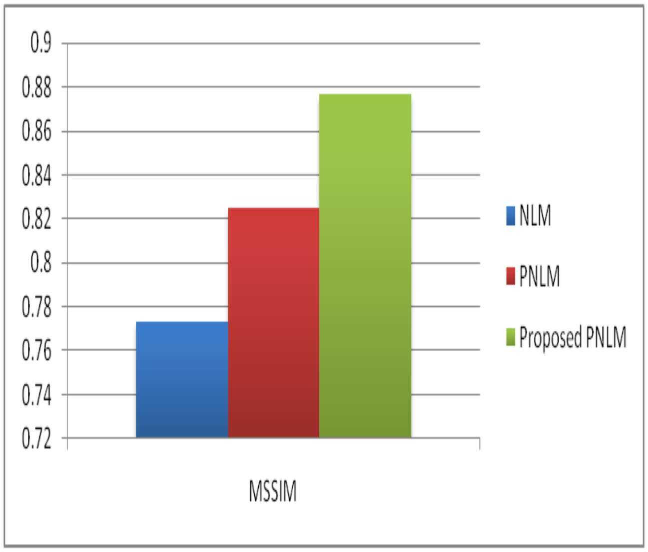


**Figure 4:** MSSIM Comparison

The proposed PNLM, NLM and existing PNLM algorithm are compared for in terms of MSSIM value for their performance scrutiny as depicted by figure 4. The proposed algorithm has maximum MSSIM value in comparison with other existing algorithms.

## V. CONCLUSION

Different filtering techniques are compared in the proposed study. The newest approach is proposed for the denoising of the MRI images. These images contain raisin noises. The improved version of NLM called PNLM is used in this study. In the proposed NLM filtering approach images are captured and applied as input. The GLCM algorithm is introduced to analyze some textual characteristics such as entropy, homogeneity and so on. The single value is returned in PSNR with the help of this GLCM algorithm. This single value is used as input in NLM approach. In these two steps, the size of window is altered according to the input provided by the GLCM algorithm. The results are analyzed on the basis of PSNR, MSE and MSSIM values. The results of NLM, PNLM and two step algorithms are compared on different images. It is observed that the two step algorithm shows good performance and enlightens the noises from the pixels which in turn enhance the value of remains.

## VI. REFERENCES

[1] V.V.K.D.V.Prasad ,P.Siddaiah and B.PrabhakaraRao, ―ANew Wavelet Based Method for Denoising of BiologicalSignals‖, IJCSNS International Journal of Computer Scienceand Network Security, VOL.8 No.1, January 2008.

[2] Carl Taswell, ―The what, how and why of wavelet shrinkagedenoising‖, Computing in Science and Engineering, pp. 12-19,May 2000., IEEE Std. 802.11, 1997.

[3] M. Wilke, B. de Haan, H. Juenger, and H. O. Karnath, "Manual,semi-automated, and automated delineation of chronic brain lesions:A comparison of methods," Neuroimage, vol. 56, no. 4, pp. 2038–2046, 2011.

[4] M. Iorio, G. Spalletta, C. Chiapponi, G. Luccichenti, C. Cacciari, M.D. Orfei, C. Caltagirone, and F. Piras, "White matterhyperintensities segmentation: a new semi-automated method.,"Front. Aging Neurosci., vol. 5, p. 76, Jan. 2013.

[5] C. Oboudiyat, H. Gardener, C. Marquez, M. Elkind, R. Sacco, C.DeCarli, and C. Wright, "Comparing Semi-quantitative andVolumetric Measurements of MRI White Matter Hyperintensities:The Northern Manhattan Study (S62.007)," Neurology, vol. 82, no.10_Supplement, p. S62.007-, Apr. 2014.

[6] P. Scheltens, F. Barkhof, D. Leys, J. P. Pruvo, J. J. Nauta, P.Vermersch, M. Steinling, and J. Valk, "A semiquantativeratingscale for the assessment of signal hyperintensities on magneticresonance imaging.," J. Neurol. Sci., vol. 114, no. 1, pp. 7–12, Jan.1993.

[7] K. H. Ong, D. Ramachandram, R. Mandava, and I. L. Shuaib,"Automatic white matter lesion segmentation using an adaptiveoutlier detection method.," Magn. Reson. Imaging, vol. 30, no. 6,pp. 807–23, Jul. 2012.

[8] JannathFirthouse.P1 ,ShajunNisha.S 2 , Dr.M.MohammedSathik, "Noise Reduction in MRI Images using Contourlet Transform and Threshold Shrinkages Techniques", (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 7 (2) , 2016, 723-728

[9] FarhaFatina Wahid, Sugandhi K., Raju G., “Fusion of Local and Non-Local Filters for denoising MRI Images”, IEEE, 2017

[10] A.G. Rudnitskii, M.A. Rudnytska, “Segmentation and Denoising of Phase Contrast MRI Image of the Aortic Lumen Via Fractal and Morphological Processing”, 2017 IEEE 37th International Conference on Electronics and Nanotechnology (ELNANO)

[11] R. Sujitha1 C. Christina De Pearlin2 R. Murugesan3 S. Sivakumar, “WAVELET BASED THRESHOLDING FOR IMAGE DENOISING IN MRI IMAGE”, International Journal of Computational and Applied Mathematics. ISSN 1819-4966 Volume 12, Number 1 (2017)

[12] Hanafy M. Ali, “MRI Medical Image Denoising by Fundamental Filters”, SCIREA Journal of Computer, February 27, 2017 Volume 2, Issue 1, February 2017

[13] DongshengJianga, Weiqiang Dou, Luc Vosters, XiayuXue, Yue Sun, Tao Tang, “Denoising of 3D magnetic resonance images with multi-channel residual learning of convolutional neural network”, February 1, 2018