MRI Denoising using Non Sub Sampled Contourlet Transform

Mohan.N[1], Pavan Kumar. K[2], Vigneshwaran.P[3], Mr.U.Maheswaran[4], Dr.R.Preetha[5]

[1,2,3]*UG Students, Department of Electronics and Communication Engineering, Rajalakshmi Institute of Technology, Chennai.*
[4]*Assistant Professor, Department of Electronics and Communication Engineering, Rajalakshmi Institute of Technology, Chennai.*
[5]*Associate Professor, Department of Electronics and Communication Engineering, Rajalakshmi Institute of Technology, Chennai.*

Abstract: *This paper deals about the De-noising techniques that have emerged into an essential practice in medical applications for the study of image processing in MRI images. To address these issues, many De-noising algorithms have been developed like LMMSE filter, Gaussian filter, median filter but has its own limitations. The ultimate aim of this paper is to introduce a new, high-performance, LMMSE filter for noise reduction in MRI images. Rician noise is the predominant noise in MRI which is a signal dependent one. Therefore, by combining LMMSE filter and Non-Sub sampled Contourlet Transform (NSCT), Rician noise can be minimized which conserves excellent characteristics of the MR brain image. For measuring the performance of the proposed method, Peak Signal to Noise Ratio (PSNR) is utilized in comparison with De-noising by LMMSE filter in Non-Sub sampled Contourlet domain. It has been estimated that the proposed method has provided good results in the chosen evaluation metrics.*

Keywords: *Magnetic Resonance Imaging, De-noising, Rician Noise, LMMSE Filter, Non-sub sampled Contourlet Transform.*

I. INTRODUCTION

It is observed that in spite of the major enhancements in the recent years the accomplishment of the effective diagnostic analysis in medical imaging mainly depends on the image being noiseless. The noise is the inaccuracy, which corrupts the image intensities and reduces the effectiveness of medical diagnosis. The MRI images usually suffer from the low Signal to Noise Ratio (SNR), particularly in brain imaging. Due to this the further activities related to imaging such as segmentation of significant features, and registration becomes problematic. Noise is introduced into the images by sensing devices, transmission errors, and compression. Most of the natural images have additive random noise, which is termed as Gaussian. However, it is identified that Rician noise affects the MRI images whose intensities are governed by Rician distribution. Hence, De-noising has significant importance in MRI imaging where the common approach for image denoising is to change the noise image into a transform domain and then filtering the transformed image coefficients. It is identified from the previous literature that several approaches exist in the form of spatial filtering methods and transforms domain filtering methods for De-noising wherein the transform domain LMMSE filtering is successfully used in the areas of medical image de-noising [3]. Moreover, NSCT transform is recently entered into the field of image de-noising. In order to denoise the MRI images more effectively, this paper presents a de-noising method to MRI images using NSCT and [6] LMMSE filter. The paper is organized into the following sections as follows Section 1 provides the research problem, reviews of previous literature regarding different de-noising methodologies as well as the overall structure of the paper. Section 2 of the paper deals with the illustration of non-sub sampled contourlet transform and Section 3 describes LMMSE filter in the NSCT [7] domain. Section 4 provides information about related works, Section 5 illustrates about the proposed methodology while Section 6 summarizes the results and discussions, and Section 7 summarizes the conclusion and future work.

II. NON SUB SAMPLED CONTOURLET TRANSFORM

NSCT is completely shift invariant, multi-scale and multi-direction expansion that has better directional frequency localization and fast implementation where it helps to achieve the similar subband decomposition as that of contourlet but without the downsamplers and upsamplers in it. The NSCT construction can be divided into two parts where one part demonstrates the non-sub sampled pyramid structure, which splits the input into a low pass sub band and a high pass sub band. The other one is non-sub sampled directional filter bank structure, which decomposes the high pass sub band into several directional subbands.

III. LMMSE ALGORITHM

Conventionally, the LMMSE method models the underlying signal value as a realization of a random variable and tries to estimate from the noisy data. The LMMSE [3] estimator originally performs this task using the sample contents within local neighborhoods; as a consequence, a straightforward implementation for the estimator is achievable. LMMSE estimator is a suitable alternative for processing the MRI images. Nevertheless, this method estimates the true signal value using the samples within a local neighborhood. Such a way, however, requires a suitable selection method of samples to be consistent with the LMMSE estimation and noise properties in MRI.

IV. RELATED WORKS

A. Contourlet Transform:

The contourlet transform uses a double filter bank structure to get the smooth contours of images. In this double filter bank, the Laplacian pyramid (LP) is first used to capture the point discontinuities, and then a directional filter bank.

The contourlet transform is **not shift invariant**.

B. Median Filter:

It is a nonlinear digital filtering technique, often used to remove noise from an image or signal. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise.

The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. The pattern of neighbours is called the "window", which slides, entry by entry, over the entire signal.

The Median Filter is performed by taking the magnitude of all of the vectors within a mask and sorted according to the magnitudes. The pixel with the median magnitude is then used to replace the pixel studied. The Simple Median Filter has an advantage over the Mean filter since median of the data is taken instead of the mean of an image. The pixel with the median magnitude is then used to replace the pixel studied. The median of a set is more robust with respect to the presence of noise. The median filter is given by Median filter.

C. Wiener filter:

Weiner filter is based on a statistical approach. In signal processing, the Wiener filter is a filter used to produce an estimate of a desired or target random process by linear time-invariant (LTI) filtering of an observed noisy process, assuming known stationary signal and noise spectra, and additive noise. The Wiener filter minimizes the mean square error between the estimated random process and the desired process. One is assumed to have knowledge of the spectral properties of the original signal and the noise, and one seeks the LTI filter whose output would come as close to the original signal as possible.

V.PROPOSED METHOD

The proposed idea explains about the noise removal technique which is explicitly concentrated on the brain image. The whole idea comprises of two core concepts: 1. Non-sub sampled contourlet transform and 2. LMMSE filtering. The objective of NSCT algorithm is splitting the frequency components into high and low-frequency components. In this paper, NSCT algorithm has to be employed for two times for the same image. The reason for this process is to get the more information on both high and low-frequency components in the particular MRI brain image.

The proposed systematic flow chart is given below:

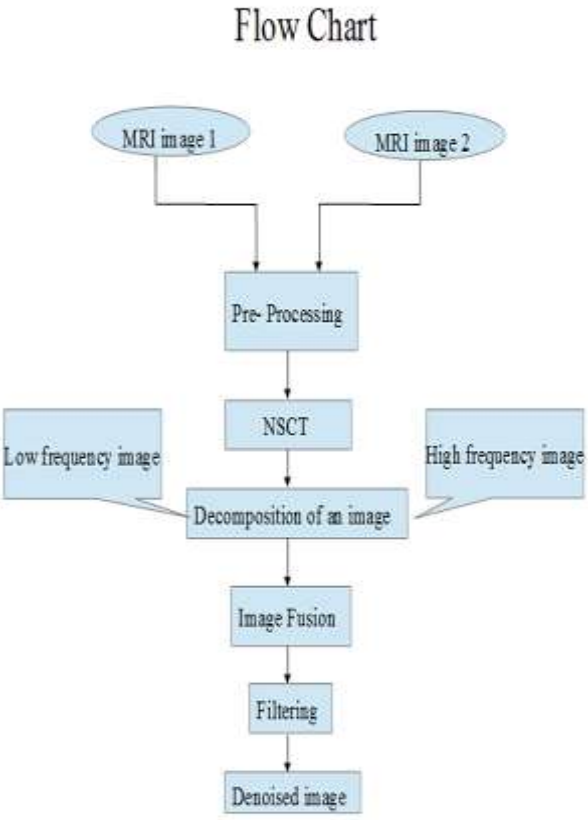
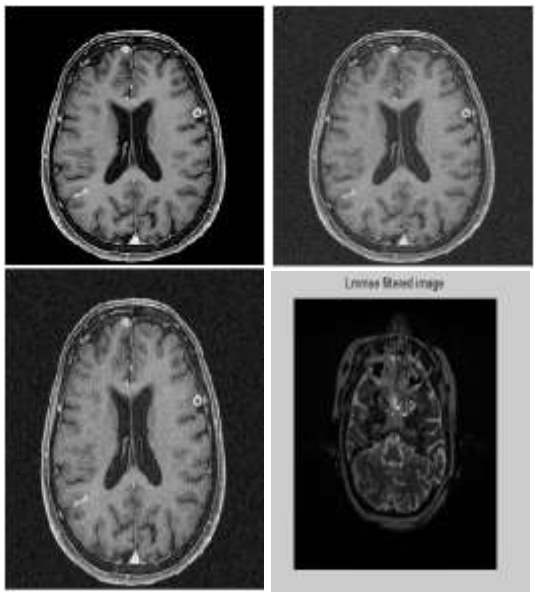


Figure: Proposed Flowchart



Denoising of Image:

(a) Original image.
(b) De-noised image by Wiener filter in Contourlet transform.
(c) De-noised image by LMMSE filter in Non-Sub sampled Contourlet transform.

VI. RESULT AND DISCUSSION

To justify the performance of our algorithm, we used datasets. The dataset is the Digital Imaging and Communications in Medicine (DICOM) dataset. The proposed algorithm was carried out using the Matlab software. The proposed algorithm performs transformation, fusion, filtering for the MRI images to remove the existing noise in the image. The application of the proposed technique can be continued to different regional images.

VII. CONCLUSION AND FUTURE WORKS

In this study, the proposed method removes the noise in an efficient manner by combining NSCT and LMMSE filtering for MRI images. This paper presents a technique where both median and mean filtering is combined to remove noise from medical images. This proposed method has been compared with mean, median and midpoint filters using numerical parameters like PSNR, SNR, and the results have been compared and analyzed with the standard pattern of noises. It has been shown that this proposed approach retains the structural details of the medical image and yet clearing out much of the noise present in the image. This experimental approach will improve the accuracy of MRI images for easy diagnosis. In this research work, the idea in future is to do experiments on restoration and enhancement process on images of ultrasound imaging has been conducted. Several aspects related to removing noise, have been addressed in detail. This work can be further enhanced for 3D Doppler images. The segmentation based feature extraction and Image texture (tissue characterization) technique for the ultrasound images can be established.

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