ISSN: 2349 - 4891

International
Journal of Recent Research and Applied Studies
(Multidisciplinary Open Access e-journal)

Noise Reduction in MRI Brain Image

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Received 20th October 2014, Accepted 25th December 2014

Abstract

In medical image processing, medical images are polluted by different type of noises. Removing of noise from medical images is now a very tricky issue in the field of medical image processing. Most eminent noise reduction methods, which are usually based on the local statistics of a medical image, are not proficient for medical image noise reduction. This paper presents a competent and simple method for Rician noise reduction from MRI Brain image. The Proposed Gaussian filter is compared with other two image filtering algorithms. The eminence of the output images is measured by the statistical quantity measures: signal-to-noise ratio (SNR), peak signal-to-noise ratio (PSNR) and mean square error (MSE).

Keywords: Rician Noise, Gaussian Filter, Median Filter, Wiener Filter, MRI Brain Image.

Introduction

In medical image processing, it is very important to obtain precise images to facilitate accurate observations for the given application. Low image quality is an obstacle for effective feature extraction, analysis, recognition and quantitative measurements. Therefore, there is a fundamental need of noise reduction from medical images. There are currently a number of imaging modalities that are used for study of medical image processing. Among the newly developed medical imaging modalities, More often Medical images are usually obtained by X-rays and MRI. MRI is an essential tool in the clinical and surgical environment due to superior soft tissue differentiation, high spatial resolution, contrast and it does not use any harmful ionizing radiation which may affect patients. Image preprocessing is used to improve the quality of images. Medical images are corrupted by different type of noises like Rician noise etc. It is very important to have good quality of images for accurate observations for the given application. MRI is a powerful diagnostic technique. However, the incorporated noise during image acquisition degrades the human interpretation, or computer-aided analysis of the images. Noise in MR images obeys a Rician distribution [1]. Unlike additive Gaussian noise, Rician noise is signal-dependent and consequently separating signal from noise is a difficult task [2]. MRI makes use of the property of nuclear magnetic resonance (NMR) to image nuclei of atoms inside the body. Magnetic resonance imaging (MRI) is often the medical imaging method of choice when soft tissue demarcation is necessary. The rest of the paper is organized as follows: section 2 explains medical image noises ,material and methods in section 3, Experimental Results in section 4 and conclusion in Section 5.

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Medical Image Noises

Noise means, the pixels in the image show different intensity values instead of true pixel values. Noise may be of different types[3]. We can model a noisy image as follows:

$$m(a,b) = p(a,b) + q(a,b) \quad (1)$$

Where p(a, b) is the original image pixel value and q(a, b) is the noise in the image and m(a,b) is the resulting noise image.

1) Gaussian Noise:

The term normal noise model is the synonym of Gaussian noise. This noise model is additive in nature and follow Gaussian distribution. Meaning that each pixel in the noisy image is the sum of the true pixel value and a random, Gaussian distributed noise value. The noise is independent of intensity of pixel value at each point. This type of noise affects the CT images.

2) Speckle Noise:

A different type of noise in the coherent imaging of objects is called speckle noise. This noise is, in fact, caused by errors in data transmission. This kind of noise affects the ultrasound images. One of the characteristic of speckle noise is that it is deterministic in

nature, i.e. two images which have been acquired under the same circumstances will suffer same level of corruption.

3) Poisson Noise (Photon Noise):

Poisson or shot photon noise is the noise that can cause, when number of photons sensed by the sensor is not sufficient to provide detectable statistical information . This noise has root mean square value proportional to square root intensity of the image. Different pixels are suffered by independent noise values. At practical grounds the photon noise and other sensor based noise corrupt the signal at different proportions . The X-ray Images are affected by this type of noise.

4) Rician Noise:

MR images are corrupted by Rician noise, which arises from complex Gaussian noise in the original frequency domain measurements. "Rician noise" depends on the data itself, it is not additive, so to "add" Rician noise to data, what we really mean is make the data Rician distributed. Here we have given four types of noises related to X-ray,CT,Ultrasound & MRI modalities. But we mainly concentrate only on MRI and its Rician Noise.

Materials and Methods

The proposed method is very promising algorithm for removing noise from MR image. To test our proposed method we took a magnetic resonance image (MRI) of human brain[4]. The human brain MRI image suffers from rician noise. We apply the filters ie median, wiener and gaussian one by one in the noised image and compare their performance to get the denoised image.

A. Median filter

The best-known order-statistics filter is the median filter, which, as its name implies, replaces the value of a pixel by the median of the gray levels in the neighbourhood of that pixel.

B. Wiener filter

It is used to reduce disturbance (noise) present in a signal by comparison with an estimation of the desired noiseless signal. The design of the Wiener filter is of different approach. The Wiener filtering is a linear estimation of the original image . The approach is based on a stochastic framework

C. Gaussian filter

It is designed to give no overshoot to a step function input while minimizing the rise and fall time. This behaviour of Gaussian filter causes minimum group delay. Mathematically, a Gaussian filter modifies the input signal by convolving with a Gaussian function. The Gaussian filter is usually used as a smoother. The output of the Gaussian filter at the moment is the mean of the input values.

First, our interest is in determining if the quality metrics based on the Mean Square Error (MSE) are sufficient tools in determining the quality of denoised images [5]. For this, we measure the SNR, PSNR and MSE of denoised images.

SNR is defined as Signal to Noise Ratio, it is calculated as :

SNR = 10log10(d/mse) (2)

PSNR is the Peak Signal-to-Noise ratio in decibels (dB). The PSNR is only meaningful for data encoded in terms of bits per sample, or bits per pixel :

PSNR = 20log10(255/sqrt(mse)) (3)

MSE is defined as mean square error :

E = abs(L-J) (4)

MSE = sqrt(mean(mean(E).^2)) (5)

Experimental Results

This section discusses the experimental results that obtained by applying the previously described median filter, wiener filter, Gaussian filter to the Rician Noise.

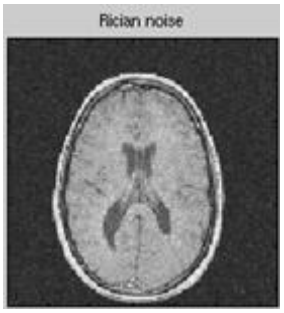


Fig 1 Noisy MRI Image

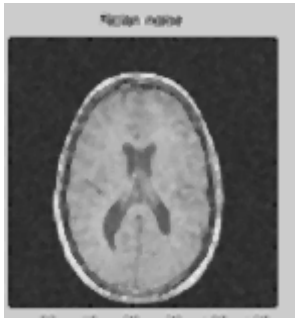


Fig 2 Median filter Effect

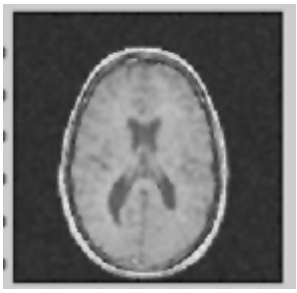
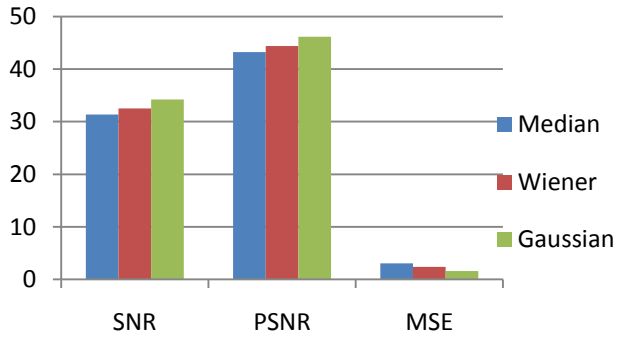


Fig 3 Wiener filter Effect

Fig 4 Gaussian filter Effect

From the above figures, result after median filter the image is slightly blurred, But the results after wiener and Gaussian are seems to be similar. In terms of quality metrics , Gaussian gives capable results. Table 1

Methods	SNR	PSNR	MSE
Median	31.3517	43.2614	3.0686
Wiener	32.4985	44.4082	2.3565
Gaussian	34.2429	46.1527	1.5769



Conclusions

In this paper, we present a simple and efficient technique to remove noise from the medical image. After finding the Rician Noise in MRI Brain Image various filtering techniques have been applied and it is found that the Gaussian filter works better for the noisy image. Through this work we have observed that the choice of filters for de-noising the medical images depends on the type of noise and type of filtering technique, which are used. It is remarkable that this saves the processing time. And also compare three types of filter and observe Gaussian filter gave the best accuracy. When compare the values of SNR,PSNR and MSE, the wiener filter retains the second place.

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