Medical Image Denoising Using Thresholding in Wavelet Domain

V. Karthick[1], S. Ashvandh[2], R. Prasanna Sundar[2], S.Venkatesh[2]
Department of Electronics and Communication Engineering,
Velammal College of Engineering and Technology, Madurai-625009.
[1] Assistant Professor, [2] UG Students.

***Abstract*--All recording devices, both analog and digital, have charracteristics that make them susceptible to noise. Noise can be random or white noise with no coherence, or coherent noise introduced by the device's mechanism or processing algorithms. We describe a method for removing noise from digital images based on a statistical model of the coefficients of an over complete multi-scale oriented basis. Medical images are facing a problem of high level components of noises. There are different techniques for producing medical images such as Magnetic Resonance Imaging (MRI), X-ray, Computed Tomography and Ultrasound, when this process happens noise is added that decreases the image quality and image analysis. Noise removal techniques are used to remove the noise or distortion from images while saving the original quality of the image while wavelet transform improves the quality of an image and reduce the noise level. The aim of this paper to characterize the Gaussian noise in wavelet transforms. Following that, a threshold based noise removal algorithm has been developed using hard and soft thresholding image optimization techniques. First the image is decomposed using Haar transform, and then the level of soft and hard threshold is selected for reducing the noise in the image and after that by calculating and comparing the PSNR & MSE of an image for every . Haar transform decomposes the discrete signal into two sub signals of half its length. One sub signal is a running average or trend and other is running difference or fluctuation. Hard thresholding is a keep or kill procedure. Soft thresholding shrinks the coefficients above the threshold in absolute value.We demonstrate through simulations with images contaminated by Gaussian noise that the performance of this method substantially surpasses that of previously published methods, both visually and in terms of mean squared error.**

Keywords— Gaussian noise, Haar wavelet, Hard thresholding, MSE, PSNR.

I. INTRODUCTION

Image noise removal has become a crucial step in processing of images and removing unwanted noisy data from the image. The image noise removal algorithms have to remove the unwanted noisy elements and keep all the relevant features of the image. The image noise removal algorithms have to tradeoff between the two parameters i.e. effective noise removal in the image and preserving the image details. The noise removal algorithms vary greatly depending on the type of noise present in the image. Each type of image is characterized by a identical noise model. Each noise model has its own probability density function which describes the distribution of noise within the image. Images play a very vital role in many fields such as astronomy, medical imaging and images for forensic laboratories. Images used for these purposes should not have noise to obtain accurate results from these images. Medical image enhancement technologies has drawn much attention since advanced medical techniques were put into use in the medical field. Enhanced medical images are desired by a doctors to assist diagnosis and manipulation because medical image qualities are often degraded by noise and other data acquisition devices, illumination conditions, etc. Therefore it is an vital task to remove the noise from medical images especially in MRI, Ultrasound, PET, SPECT, digital Mammogram and Ultrasound images. Selection of correct filter is a difficult task which is overcome by Wavelet Transform. In this paper, unwanted noisy components can be thresholded without disturbing the important features of the image. We calculate PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error) by using those orthogonal wavelets and then compare the resultants.

Introduction to wavelet transform: In most of the applications of image processing, it is essential to manipulate a digital signal. If the data will be transformed into some other domain then the structure and features of the signal may be better understood. There are various transforms available like Fourier transform, Hilbert transform, Wavelet transform, etc. The wavelet transform is far better than Fourier transform because it gives frequency representation of a signal at any given interval of time, but Fourier transform gives only the frequency-amplitude output of the raw signal, but the time information is lost. So we cannot use the Fourier transform where we need time as well as frequency domain details at the same time.

Haar wavelet: Haar wavelet is one of the oldest and simplest type of wavelet. Like other wavelet transforms, the Haar Transform separates the discrete signal into two sub-signals of half its length. One sub-signal is a analyzing average or trend and other sub-signal is running difference or fluctuation. The merits of Haar wavelet is that it is fast, memory efficient and conceptually simple.

II. INTRODUCTION TO NOISE REMOVAL

Introduction to Image Denoising :

Image noise removal has become a critical step in processing of images and removing unwanted noisy data from the image. The image noise removal algorithms have to remove the unwanted noisy elements and keep all the vital features of the image. The image noise removal algorithms have to tradeoff between the two parameters i.e.

effective noise removal and preservation of image details. The noise removal algorithms vary greatly depending on the type of noise present in the image. Each type of image is characterized by a unique noise model. Each noise model represents a probability density function which describes the distribution of noise within the image. Images play a very vital role in many fields such as astronomy, medical imaging and in forensic applications. Images used for these purposes have to be noise free to obtain accurate results from these images. Medical image enhancement technologies have attracted much attention since advanced medical devices were put into use in the medical field. Enhanced medical images are desired by a surgeon to assist diagnosis and interpretation because medical image qualities are often degraded by noise and other data acquisition devices, illumination conditions, etc. Therefore it is an vital task to remove the noise from medical images like MRI, Ultrasound, PET, SPECT, digital Mammogram and Ultrasound images. Selection of proper filter is a tough task which is overcome by Wavelet Transform.

III. METHODOLOGY

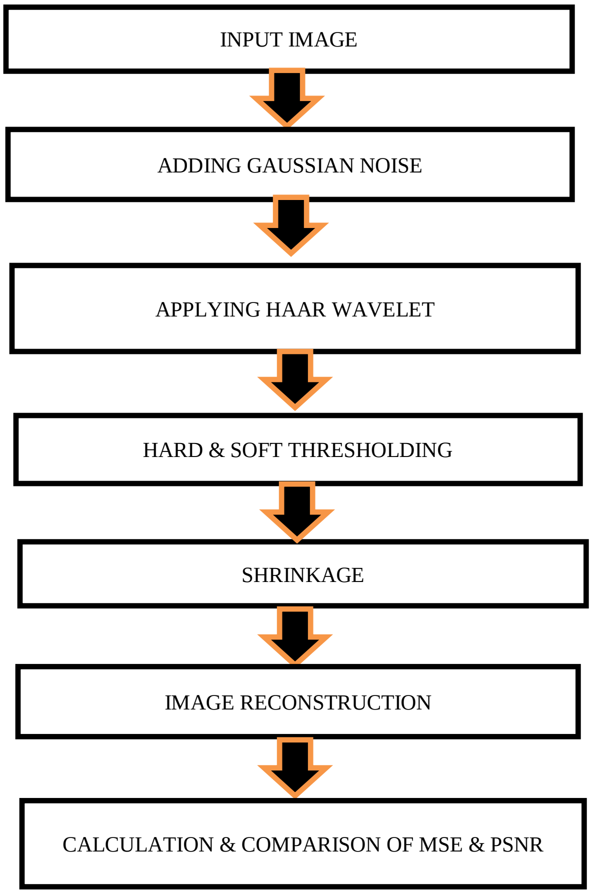
In medical images many coif1, coif3 etc can be used fornoise removal but we have used haar at certain level of soft and hard threshold for decomposition of noisy images and reconstruction of the resultant images. PSNR and MSE of these images are calculated for comparison of results of different wavelets.

Noise removal Algorithm:

Input Image : Experiments are conducted ongray scale medical images like Brain Tumour, MRI then Gaussian noise is added at different noise levels σ= 0.02, 0.03.

Wavelet Selection: We select a wavelet Haar among various wavelets. Haar transform separates the discrete signal into two subsignals half of its length. It is useful in noise removal as high frequency coefficient spectrum reflect all high frequency changes.and the remaining pixels to a background value. In this approach we have used two thresholding i.e, hard and soft thresholding.

Flow chart of Methodology:



Threshold Selection : Thresholding is the simplest method of noise removal in image.In this from a gray scale image, thresholding can be used to create binary image. Thresholding is done to segment an picture by setting all pixels whose intensity values above a threshold to a foreground value.

Wavelet Shrinkage: The wavelet shrinkage is a signal noise removal technique developed based on the concept of thresholding the wavelet coefficients. Wavelet coefficients having small absolute value are considered to encode mostly noise and very finedetails of the signal. In contrast, the vital information is encoded by the coefficients having large absolute value. Removing the small absolute valu coefficients and thenreconstructing the signal should produce signal with low noise.

Reconstruction of an Image: Opening the Noise Reduction subsystems shows the same wavelet blocks but with a soft or hard threshold is applied to the transformed signal bands. The high frequency corrupted data in image is decreasedby attenuating the higher frequency bands,. We can adjust the threshold levels to see the effects of attenuation on the noise removal characteristics of the system.

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IV. MSE AND PSNR

Peak Signal to Noise Ratio:

Peak signal to noise ratio(PSNR) is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. It is generally expressed in terms of logarithmic decibel scale.

$$PSNR=10\log_{10}(MAX_i^2/MSE)$$

$$=20\log_{10}(MAX_i/MSE)$$

Where MAXi is the maximum fluctuation in the input image data type, For instance, if the input image has a floating-point double-precision data type, then MAXI is 1. If it has an 8-bit unsigned integer data type, R is 255, etc.

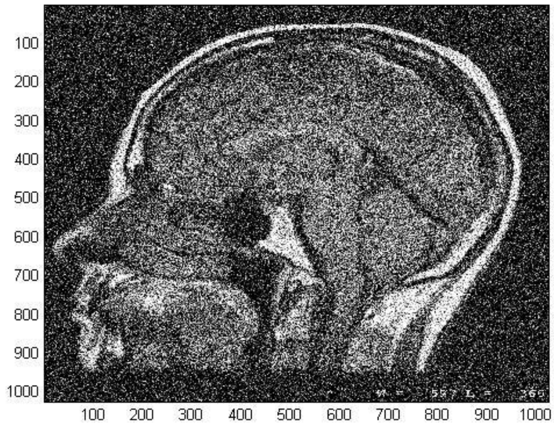
Mean Square Error: In statistics, the mean squared error (MSE) of an estimator finds the average of the squares of the "errors", that is, the difference between the estimator and what is estimated. MSE is a risky function, corresponding to the predicted value of the squared error loss or quadratic loss. The difference occurs because of the random property or because the estimator doesn't account for information that could produce a mostaccurate estimate. The mean square error is used aspart of the digital image processing method to check for errors. Two MSEs are obtained and then compared to determine the accuracy of an image.

V. EXPERIMENTS AND RESULTS

The image that has added noise is reconstructed using hard and soft thresholding. Threre is significant improvement in the PSNR of the thresholded images. And we have come to solution that soft thresholding provides more promising result than hard thresholding.

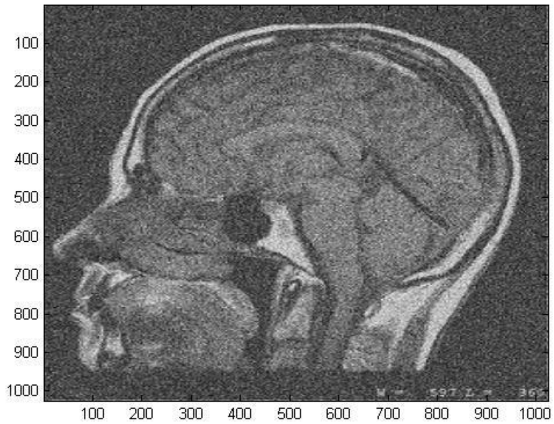
ORIGINAL IMAGE

NOISY IMAGE



HARD THRESHOLDED IMAGE

SOFT THRESHOLDED IMAGE



NOISE VARIANCE	HARD MSE	HARD PSNR	SOFT MSE	SOFT PSNR
0.02	0.0184	65.4800	0.0179	66.1881
0.03	0.0349	62.7028	0.0300	63.0780

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