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Denoising Of Gaussian Noise Using Shrinkage Method with Daubechies Wavelet Transform

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Abstract— Image Denoising is a vital part in various image processing and computer application. The important role of a good image denoising algorithm is that it should entirely remove noise and preserving the edges. In this paper an efficient denoising algorithm using Daaubechies Wavelet transform is used. Visu Shrink and Sure shrink technique is used for noise removal. Performance metrics like Mean Square Error (MSE) and Peak Signal to noise Ratio (PSNR) is evaluated for these Shrinking techniques.
Keywords— Peak Signal to Noise Ratio (PSNR), Discrete Wavelet Transform (DWT), Mean Square Error, VISU shrink, SURE shrink

I. INTRODUCTION

Images are usually corrupted by noise in its acquisition and Transmission [1]. The main objective of Image denoising techniques is necessary to remove the noise frequently occurring in day to day life, at the extent of without compromising the signal features. Noise reduction is a very challenging problem due to many reasons. The first reason is change in characteristics and nature of the noise signal that varies from application to application and these signals also varies with respect to time. Therefore it is very difficult to develop an effective algorithm that works in diversified environments. The second reason is the objective of a noise reduction model is highly dependent on the particular context and application. The image corrupted by additive white Gaussian noise (AWGN) is classical importance in image processing. The images corrupted by noise are common during its image acquisition, processing, image compression, transmission over the channel [2]. In the last few decades several successful algorithms have been evolved which focuses on removing the noise from the corrupted image to increase the overall quality of the reconstructed image [3]. The additive white Gaussian noise can be removed by a number of Thresholding and wavelet shrinkage techniques. Donoho and Johnston proposed hard and soft Thresholding methods for Denoising the corrupted by various noise. Wavelet shrinkage method introduced by Donoho is one of the famous technique which uses wavelet transform.

II. NOISE CATEGORY

The classification of noise relies mainly on the characterizing probabilistic specifications. There are the four types of noise categories in image processing [3].

Gaussian noise
Salt and Pepper Noise
Poison noise
Speckle Noise

A. Gaussian Noise

The Gaussian noise can be modelled in terms of amplifier noise, which is additive Gaussian, and hence independent at each pixel and intensity of the signal. This noise follows probability distribution function and is most frequently occurring in digital images [5].

B. Salt And Pepper Noise

Salt and Pepper noise this noise is also called Impulsive noise. This noise is generally seen on digital images. This noise consists of black and white pixels. The typical example of impulse noise which is very much frequently occurring in medical image is salt and pepper noise. This noise is represented in terms of black and white pixel. One of the popular cause of this noise is bit errors during transmission and Analog to digital conversion errors in electronic equipment.

C. Poisson Noise

This noise mainly occurs in medical application like X-ray imaging and Infra-red imaging. A Poisson noise can be stated in terms such that each pixel y of an image f(y) is derived from Poisson distribution function with parameter c=f(y) where c is the original image to be drawn.

D. Speckle Noise

The speckle noise can be modelled as multiplicative noise and is given by $y= a_{ij}b_{ij} +c_{ij}$ Where 'y' represent the noisy pixel and 'a' represent the noisy free pixel, 'b' signify the multiplicative noise and 'c' indicate the additive noise respectively i,j represents the location of pixel [4].

III.PROPOSED METHOD

Image denoising is one of the major problems which are encountered in image processing. Various efficient noise removal techniques and algorithms are available which proves to be fruitful for denoising. In order to fulfil the stated objective the proposed block diagram for image denoising is shown in fig1

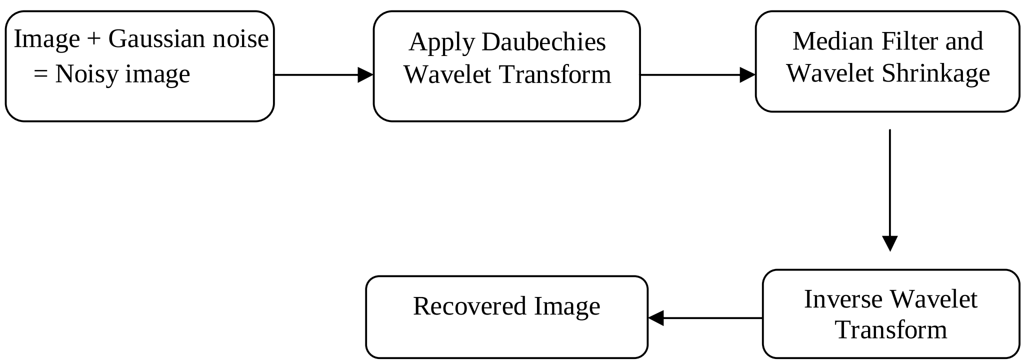

Fig 1: Proposed block diagram for Denoisng Gaussian noise

A. Discrete Wavelet Transform

Wavelet denoising attempts to remove the noise present in the signal while preserving the signal characteristics, regardless of its frequency content. As the discrete wavelet transform (DWT) corresponds to basis decomposition, it provides a non-redundant and unique representation of the signal. Several properties of the wavelet transform, which make this representation attractive for denoising, are

Multiresolution - Image details of different sizes are taken into consideration

Sparsity - Most of the wavelet coefficients are small in magnitude.

Edge detection – Edges coincides with the large frequency component.

Edge clustering – Coefficient bound within the sub-band form clusters.

As DWT is applied on the noisy image, the image is spread into four different sub-parts LL, HL, LH and HH [6]. The wavelet transform used for denoising is Daubechies Wavelet Transform. For the stated objective db2, db5 and db7 has been taken into consideration, for checking the performance of the reconstructed image.

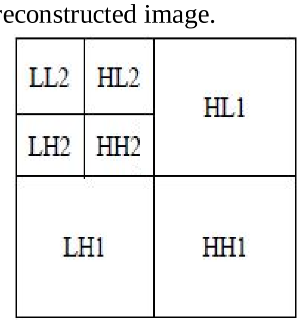

Fig 2: Two level decomposition of Noisy image

The application of DWT on the image gives the wavelet coefficient; the decomposition up to 2 levels is shown in fig2. The image is

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decomposed by taking LL sub-band into account [2].

B. Median Filter

The application of DWT divides the image into sub-bands. The median filter which is a non-linear filter is applied on the Approximation (LL) sub-band. This filter removes the noise by replacing the middle pixel value with the median of all the pixels in the neighbourhood of kernel window. In this paper a mask of size of 3×3 is taken and it gives the good result.

C. Wavelet Shrinkage Technique

The wavelet coefficient obtained by applying DWT on the noisy image is used to compare against a threshold for estimation of noise. Two wavelet shrinkage techniques are being considered for threshold estimation [15]. The techniques are VISU shrink and SURE shrink.

1) VISU shrink: This shrinking technique was introduced by Donoho and it follows Hard Thresholding principle. This Thresholding technique is suitable for removal of Gaussian noise and does not holds good for denoising of speckle noise. This is also called as universal threshold. The threshold equation is given by

$$T= \sigma\sqrt{2\log n} \qquad (1)$$

Where,

σ =Standard deviation of noise

n= number of pixel elements in the image

The term σ is estimated by [2]

$$\hat{\sigma} = \frac{\text{median(Yij)}}{0.6745}$$

This asymptotically yields a mean square error (MSE) estimate as M tends to infinity. As M increases, we get bigger and bigger threshold, which tends to over smoothen the image.

2) SURE shrink: This SURE Shrink threshold was developed by Donoho and Johnston [8],[11]. For each sub-band, the threshold is determined by minimizing Stein's Unbiased Risk Estimate (SURE) for those coefficients. SURE is a method for estimating the loss $(\mu'-\mu)^2$ k in an unbiased fashion, where μ' is the estimated mean and μ is the real mean. The threshold is calculated as follows:

$$t^*=\min(t, \sigma\sqrt{2\log 2n}) \qquad (2)$$

Where,

σ =Standard deviation of noise

n= number of pixel elements in the image

Donoho and Johnston [8] pointed out that SURE Shrink is automatically smoothness adaptive. This implies that the reconstruction is smooth wherever the function is smooth and it jumps wherever there is a jump or discontinuity in the function [16]. This method can generate very sparse wavelet coefficients resulting in an inadequate threshold.

IV. RESULTS AND DISCUSSION

In this section simulation results for denoising Gaussian noise with VISU shrink and SURE shrink is discussed. It is MATLAB R2013b on windows PC with 4 GB Ram. The denoised image for Cameraman shown in fig3.

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a) Original Image

b) Noisy Image

c) VISU shrink (with db2)

d) SURE shrink (with db2)

Fig3. Cameraman Image Denoised by Proposed Technique

The performance of the reconstructed image can be measured using Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE). Greater is the PSNR the more pleasant image is recovered. The shrinkage technique applied in this paper minimises the MSE. The PSNR and MSE [7] is calculated by Table 1 shows the PSNR for proposed denoising algorithm and Table 2 shows MSE.

$$PSNR= 10\log 10 \left[(255*255)/ MSE\right] \ \text{dB} \tag{3}$$

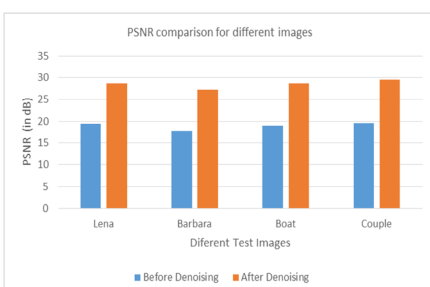
$$MSE=\sum_{i=1} \sum_{j=1} \left[x (i, j)-y (i, j)\right]^2 \tag{4}$$

Table 1: PSNR comparison for Different test images

Images	PSNR(in dB)	
	Before Denoising	After Denoising
Lena	19.403	28.598
Barbara	17.767	27.217
Boat	18.98	28.712
Couple	19.540	29.516

Table2: MSE comparison for Different test images

Images	MSE	
	Before Denoising	After Denoising
Lena	102.242	25.1642
Barbara	104.231	25.572
Boat	120.2418	27.001
Couple	112.452	24.7085



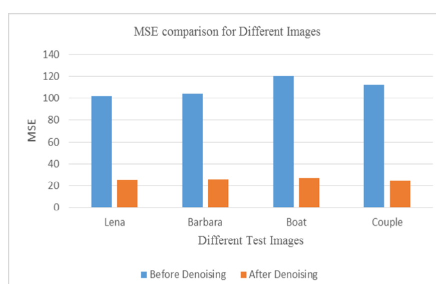


Fig 4: Graphical representation of PSNR and MSE

The comparison of different shrinkage techniques quality has been produced with the help of PSNR and MSE table which is shown in table3 and table4 respectively.

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Table3: PSNR Comparison for VISU and SURE shrink

Noise variance variance	PSNR(in dB)	
	VISU shrink	SURE shrink
0.01	28.525	31.264
0.02	27.929	30.256
0.04	26.224	29.542
0.05	24.989	27.789

Table4: MSE Comparison for VISU and SURE shrink

Noise variance	MSE	
	VISU shrink	SURE shrink
0.01	121.253	8.737
0.02	140.28	9.23
0.04	165.274	11.615
0.05	198.13	13.123

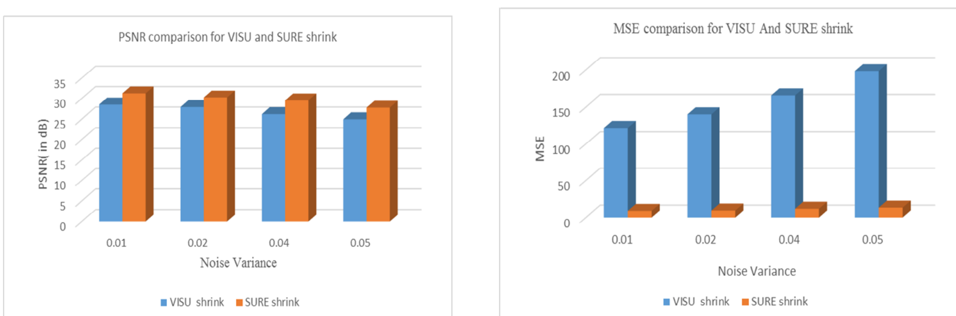

Fig 5: Graphical representation of PSNR and MSE for VISU and SURE shrink

V. CONCLUSION

An efficient denoising algorithm for removal of Gaussian noise was proposed using median filtering and Wavelet shrinkage technique. The results have been shown by adding noise variance of 0.02 and the noise was removed using VISU shrink and SURE shrink technique. An experimental result shows that SURE shrink give better PSNR and hence it gives pleasant image.

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