A REVIEW WAVELET THRESHOLDING APPROACH FOR NOISE REDUCTION IN DIGITAL IMAGE PROCESSING

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ABSTRACT

The original image corrupted by Gaussian noise is a long established problem in image processing. It is statistical type of noise. It is based on Probability density function and this probability density function is always equal to normal distribution. There are specific types of filters used for Gaussian noise reduction such as spatial filter, in an image when smoothing occurs undesirable results may occur in the blurring of fine-scaled image edges and details due to the blockage of high frequencies. In this paper the necessary idea of an uncorrected image from the noise image identified by "noise reduction method" choosing the excellent way play an important role for getting the desired image.

In this review paper, This noise is removed by using wavelet thresholding by focusing on statistical modelling of wavelet coefficients and the optimal choice of thresholds called as image de-noising. threshold is driven in a Bayesian technique a denoising method is presented for noise reduction in Ultrasound images. This paper proposes an efficient method based on linear filtering for images which is corrupted due to Gaussian noise. The method consists in linear filtering of proper wavelet coefficients of the image, corresponding to diagonal and vertical details. The proposed denoising method has good performance and the effectiveness of the proposed method is well demonstrated by experiments on both standard image and real images.

Keywords: *Thresholding, Bayes Shrink, wavelet transfom, Gausian noise.*

INTRODUCTION

An image is often corrupted by noise in its acquisition and transmission. Noise is one of the major factors that affect the quality of the image. Noise reduction in the digital image processing is the main focus of this project. As noise degrades the quality of the image, a wavelet thresh holding method is used for the reduction of the noise from the image. Thresholding is a simple non-linear technique, which operates on one wavelet coefficient at a time. According to these threshold the pixel of the image are processed , each coefficient is threshold by comparing against threshold, if the coefficient is smaller than threshold, set to zero; otherwise it is kept or modified. There are two types of threshold hard threshold and soft threshold..

SPATIAL BASED NOISE REDUCTION

Spatial filters like mean and median filter are used to remove the noise from image. But the disadvantage of spatial filters is that these filters not only smooth the data to reduce noise but also blur edges in image. Therefore, Wavelet Transform is used to preserve the edges of images.

FFT BASED NOISE REDUCTION

FFT based noise reduction method is introduced which is a low pass filtering technique and it is unable to preserve sharpness of the edges as the basis function of FFT is not being localized in terms of time or space domain .This problem can be resolved by wavelet transform as of its localized nature in time & space domain and performs noise reduction with edge preservation.

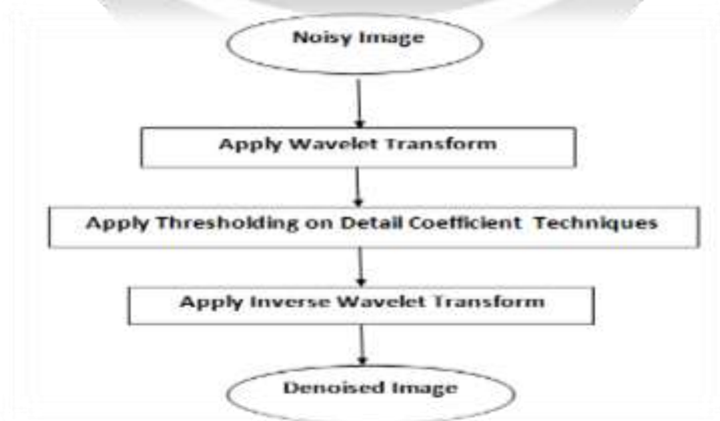
WAVELET TRANSFORM BASED NOISE REDUCTION

Wavelet is considered as an alternative to the short time Fourier transforms. It is advantageous over FFT because it provides desired resolution in time domain as well as in frequency domain. DWT of a noisy image consists of number of coefficients having high Signal to Noise Ratio(SNR) while relatively large number of coefficients is having low SNR. After removing the coefficients with low SNR, the image is reconstructed using inverse DWT. Time and frequency localization is simultaneously provided by Wavelet transform. Moreover, wavelet methods represent such signals much more efficiently than either the original domain or Fourier transform. Wavelet thresholding is a signal estimation technique that benefit from the capabilities of Wavelet transform for signal de noising. It removes noise by killing coefficients that are irrelevant relative to some threshold. Several studies are there on thresholding the Wavelet coefficients. A wave is an oscillating function of time or space and is periodic. The wavelets are localized waves. They have their own energy concentrated in time and are suited to analysis of transient signals. As Fourier Transform uses waves to study signals, Wavelet Transform uses wavelets of finite energy In wavelet analysis the signal to be analyzed is multiplied with a wavelet function and then the transform is computed for each segment generated. Wavelet Transform, at high frequencies, gives good time resolution response and poor frequency resolution, as at low frequencies, Wavelet Transform gives good frequency resolution and poor time resolution. The wavelet transform (WT) is a powerful tool of signal processing for its multiresolutional possibilities. Unlike the Fourier transform, the WT is suitable for handling the non-stationary signals – variable frequency with respect to time Continuous Wavelet Transform For a prototype function ψ (t) $\in L2(\Re)$ called the mother wavelet, the family of functions can be obtained by shifting and scaling this ψ (t)

$$CoWT_f\ (a,b) = \int_{-\infty}^{\infty} \Psi_{a,b}^{*}\ (t) f(t) dt = \langle \Psi_{a,b}(t) f(t) \rangle$$

$$\Psi_{a,b}(t) = \frac{1}{\sqrt{a}} \Psi\left(\frac{t-b}{a}\right)$$

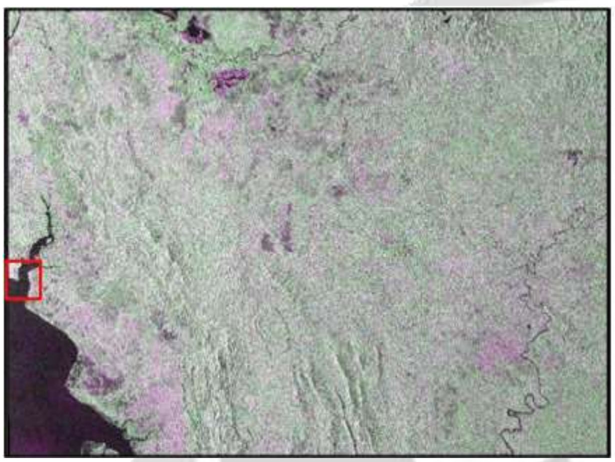
FLOW CHART

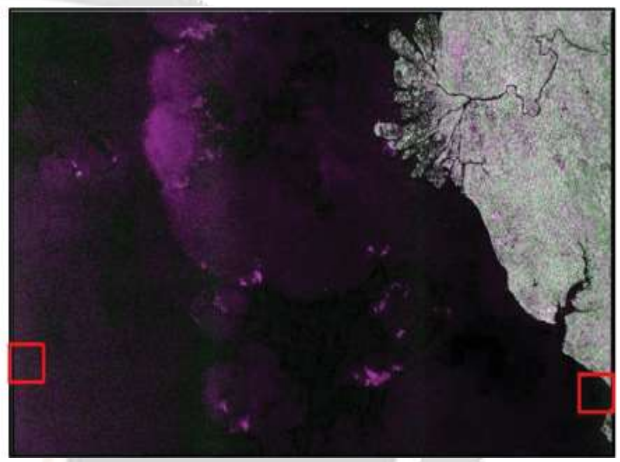


1. Read the noisy image as input
2. Perform DWT of noisy image and obtain Wavelet coefficient
3. Estimate noise variance from noisy image
4. Calculate threshold value using various threshold selection rules or shrinkage rule
5. Apply soft or hard thresh holding function to noisy coefficient
6. Perform the inverse DWT to reconstruct the denoised image.

IMAGE NOISE

Image noise is a random variation of brightness or color information in images. It can be produced by sensor or circuitry of a scanner or digital camera. Noise in digital images arises during image acquisition and/ or transmission. Images are corrupted with various type of noises. So it is very difficult to get useful information from noisy images. That is why noise reduction techniques are very important subject nowadays.





Gaussian Noise:
It is statistical type of noise. It is based on Probability density function and this probability density function is always equal to normal distribution. There are specific types of filters used for Gaussian noise reduction such as spatial filter, in an image when smoothing occurs undesirable results may occur in the blurring of fine-scaled image edges and details due to the blockage of high frequencies .

Impulse Noise:
Impulsive noise is sometimes called as salt-and- pepper noise or spike noise. This kind of noise is usually seen on images. It represents itself as arbitrarily occurring white and black pixels. An image that contains impulsive noise will have dark pixels in bright regions and bright pixels in dark regions. It can be caused by dead pixels, analog-to-digital converter errors and transmitted bit errors.
Shot Noise:
One of the most important types of electronic noise is shot noise which originates from the electric charge. This type of noise is added during time of capturing of an image.

Speckle Noise.
Speckle is a 'noise' which reduces the quality of the Ultrasound images and synthetic aperture radar (SAR) images. For image interpretation difficulties, speckle noise is more serious problem in SAR images.

Discrete Wavelet Transform (DWT)

The discrete wavelet transform (DWT) is a linear transformation that operates on a data vector whose length is an integer power of two, transforming it into a numerically different vector of the same length . It separates data into different frequency components, and then matches each component with resolution to its scale. DWT is computed with a cascade of filters followed by a factor 2 sub sampling

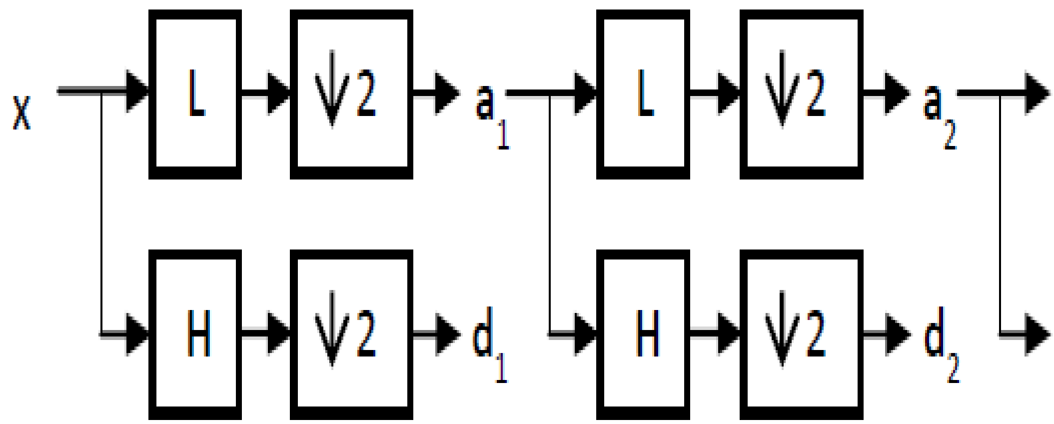
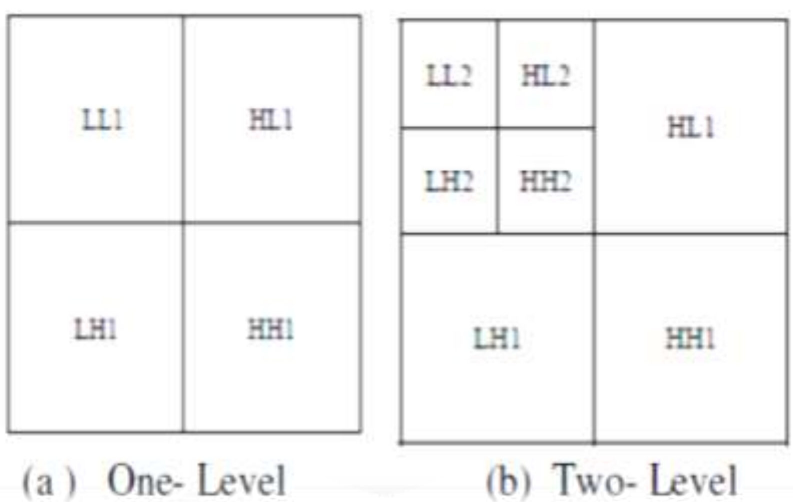


Fig: Discrete Wavelet Transform Tree

H and L denotes high and low-pass filters respectively, ↓2denotes sub sampling.
Sub bands and critically sampled by applying DWT as shown in Fig. These sub bands are formed by separable applications of horizontal and vertical filters. Sub-bands with label LH1, HL1 and HH1 correspond to finest scale coefficient while sub-band LL1 represents coarse level coefficients. The LL1 sub band is further decomposed and critically sampled to find out the next coarse level of wavelet coefficients as shown in Fig. It results in two level wavelet decomposition.



THE WAVELET THRESHOLD TECHNIQUE

Wavelet thresholding is a nonlinear technique which apply only one coefficient at a time according to different characteristics various kind of techniques are used.

$$f(x) = s(x) + n(x)$$

In which, f(x) is the signal with noise,

S (x) is the original signal,

N (x) is the Gaussian noise.

The soft-thresholding rule is chosen over hard-thresholding, for the soft-thresholding method Yields more visually pleasant images over hard thresholding.

Thresholding techniques are used for such de-noising process. Hard Thresholding is a keep or kill rule whereas Soft Thresholding shrinks the coefficients above the threshold in absolute value. It is a shrink or kill rule.

Soft Thresh holding has major advantages over Hard Thresh holding. Soft Thresh holding reduces the abrupt sharp changes and provides an image whose quality is not affected. Due to these advantages, Soft Thresh holding is more frequently used . In MATLAB, by default, hard Thresholding is used for compression and soft Thresholding for denoising.

Many wavelet based thresholding techniques like Visu shrink, Oracle Shrink, Normal shrink have proved better efficiency in image denoising. For image denoising, however, Visu Shrink is known to yield overly smoothed images. This is because its threshold choice, _2logM (called the universal threshold and is the noise variance), can be unwarrantedly large due to its Dependence on the number of samples, which is more than 105 for a typical test image of size 256*256 . Sure Shrink uses a hybrid of the universal threshold and the sure threshold, derived from minimizing Stein's unbiased risk estimator has been shown to perform well. In this paper, we propose a framework and a near-optimal threshold more suitable for image denoising based on Bayesian analyzing the statistical parameters of the wavelet coefficients that outperforms the traditional ones, improving the denoised results significantly.

Threshold Selection Rules

In image denoising applications PSNR needs to be maximized, hence optimal value should be selected . Finding an optimal value for thresholding is not an easy task. if we select a smaller threshold then it will pass all the noisy coefficients and hence resultant images may be **noisy** but larger threshold makes more number of coefficients to zero, which provides smoothness in image and image processing may cause blur and artifacts, and hence the resultant images may loss signal values.

PROPOSED ALGORITHM

Adaptive thresholding : This section focuses on the estimation of the GGD parameters, which in turn yields a data-driven estimate of that is adaptive to different subband characteristics. The noise variance needs to be estimate first. In some situations, it may be possible to measure based on information other than the corrupted image. If such is not the case, it is estimated from the sub band by the healthy median estimation

$$\sigma\hat{} = \text{Median}\,(|Y_{ij}|)\,/\,.6745 \quad \text{-- (1)}$$

Where

$$Y_{ij} \in \text{subband}HH_1$$

Recall the observation model is Y = X + U, with X and U independent of each other, Where n x n is the size of the sub band under consideration. Thus

$$T^{\wedge}_{B}(\sigma_x) = \frac{\sigma^{\wedge}2}{\sigma^{\wedge}X} \quad \text{------ (2)}$$

Where

$$\sigma^2_y = \sigma^2_x + \sigma^2 \quad \text{----- (3)}$$

$$\sigma^{\wedge}_x = \sqrt{\max\left(\sigma^{\wedge 2}_y - \sigma^{\wedge 2}, 0\right)} \quad \text{---(4)}$$

$$\sigma^{\wedge 2}_y = \frac{1}{n^2}\sum_{i,j=1}^{n}\left(X_{ij}^{2}\right) \quad \text{---- (5)}$$

$$T^{\wedge}_{B}(\sigma_x) = \max\left(|y_{ij}|\right) \quad \text{------ (6)}$$

The above equation shows the probalistics function which is proposed by scientist bayes .so, this method is called as B Wavelet Thresholding Bayesian shrink. And below equation shows the optimal threshold.

VARIOUS SHRINKING METHOD

There are various image shrinkage methods based on wavelet denoising. Some popular threshold selection methods for image denoising are visu Shrink, sure Shrink, bayes Shrink, Prob Shrink, Block Shrink and Neigh Shrink Sure.

BAYES SHRINK

The Bayes Shrink method has been attracting attention recently as an algorithm for setting different thresholds for every sub band. Here sub-bands refer to frequency bands that are different from each other in level and direction. Bayes Shrink uses soft thresholding.

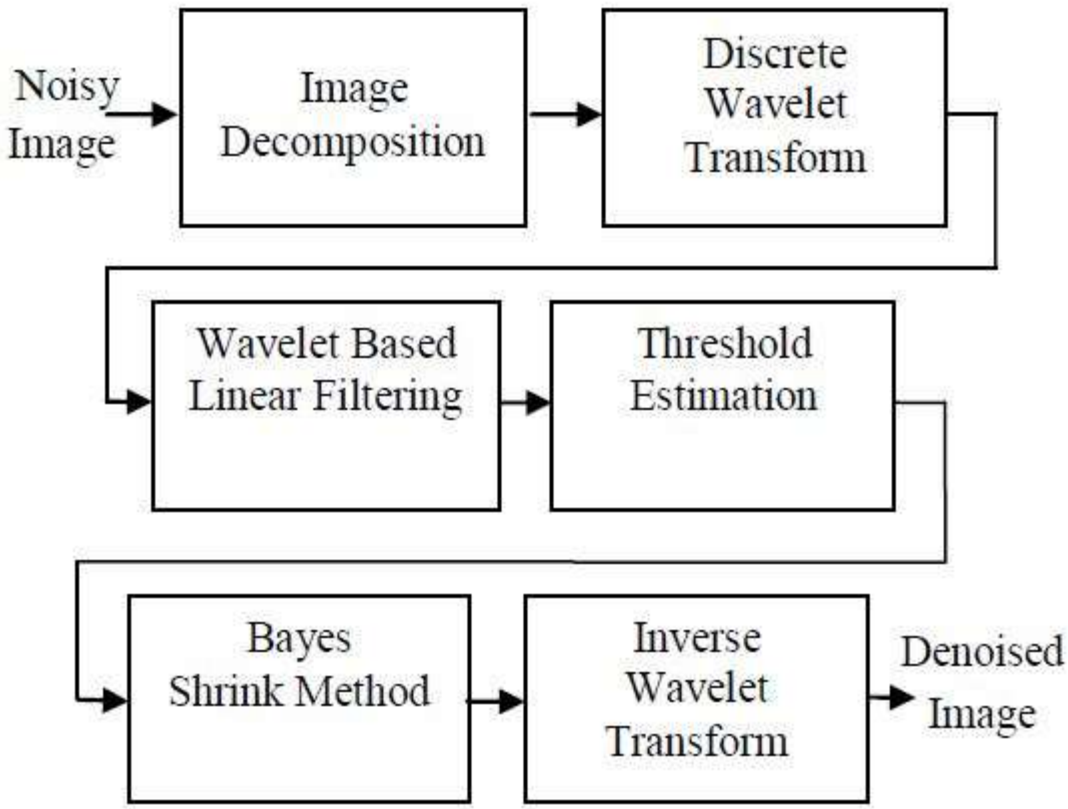


Figure: Block Diagram of Proposed Method

The purpose of this method is to estimate a threshold value that minimizes the Bayesian risk assuming Generalized Gaussian Distribution (GGD) prior. Bayes threshold is defined as,

Here threshold estimation criteria called BayesShirnk estimation, as described below. BayesShrink assumes generalized Gaussian distribution for the wavelet coefficients in each detail of sub band and uses a Bayesian mathematical framework to find the best threshold that minimizes the Bayesian risk, expressed as

$$\sigma_B = \frac{\lambda_{noise}^2}{\lambda_{Signal}} = \frac{\lambda_{noise}^2}{\sqrt{\max(\lambda_G^2 - \lambda_{noise}^2, 0)}}$$

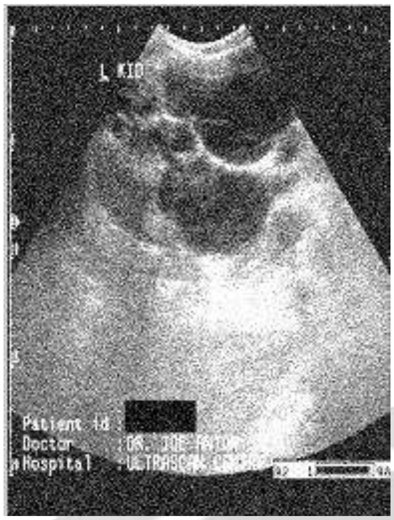
$$\lambda_G^2 = \frac{1}{P_s} \sum_{x,y=1}^{Ns} V_{xy}^2$$

Ps is the number of wavelet coefficients Vxy on the sub band under consideration. A robust estimate of noise variance uses the median absolute value of the wavelet coefficients, which is insensitive to isolated outliers of potentially high amplitude, defined as

$$\lambda_{noise} = \frac{\text{median}(|V_{xy}|)}{0.6745} \quad , V_{xy} \in \text{ subband HH}$$

Where,

Vxy is HH wavelet coefficients which forms the finest decomposition levels.



NOISED

DENOISED

CONCLUSION

Based on wavelet noise reduction method are commonly used to remove the noise in the noisy image .wavelet thresholding approach is enhance the quality of image provide the better result to reduce the noise. In this paper we apply the baysian shrinking method, Mother of wavelet technique by which we analyze the improvement of error. It provides better resolution for approximating the signals. Wavelets are having high frequency resolution than Fourier transform. Wavelet is powerful and efficient than Fourier transform. in both space and time. It provides better resolution for approximating the signals.

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