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An improved threshold estimation technique for ovary ultrasound image denoising

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Abstract: Ovarian cancer is the fifth most common cancer among women and it causes more deaths than any other type of female reproductive cancer. The risk for developing ovarian cancer appears to be affected by several factors. The more children a woman has and the earlier in life she gives birth, the lower her risk for ovarian cancer. Certain genes defects (BRCA1 and BRCA2) are responsible for a small number of ovarian cancer cases. A survey of different digital image processing techniques used in enhancing the quality and information content in ovary ultrasound image is presented. Image denoising is a procedure in digital image processing aiming. The simulation results show that the proposed threshold estimation technique has superior features compared to conventional methods. This makes it an efficient method in ovary image denoising applications; it can also remove the noise and retain the image details better is very essential to keep the data close to originality. Image denoising still remains the challenge for researchers because noise removal introduces artifacts and causes blurring of the images. Medical ultrasonography is one of the popular techniques for imaging diagnosis and is preferred over other medical imaging modalities because it is non-invasive, portable and does not provide any harmful radiations. The prime focus of this paper is related to the pre processing of an ovary image. The pre- processing being worked upon is the denoising of images. In this paper, a new threshold estimation technique has been presented along with the standard thresholding and filtering techniques and a comparative analysis of different denoising methods.

Keywords: Wavelet-transform, MATLAB, Threshold function, Salt & Pepper noise, Median filter, Wiener Filter, PSNR.

I. INTRODUCTION

In daily life digital images plays an important role in many applications such as satellite television, magnetic resonance imaging, computer tomography as well as in areas of research and technology in geographical information systems and astronomy. Data sets collected by image sensors are generally contaminated by noise. Imperfect instruments, problems with the data acquisition process, and interfering natural phenomena can all degrade the data of interest. Thus, the first step shall be denoising before the images data are analyzed. It is necessary to apply an efficient denoising technique to compensate for such data corruption. Image denoising still remains a challenge for researchers because noise removal introduces artifacts and causes blurring of the images. An image is often corrupted by noise in it is acquition and transmission. Image denoising is used to remove the additive noise and, that retaining as much as possible the important signal features. In the recent years there has been a fair amount of research on wavelet thresholding and threshold selection for signal denoising because wavelet provides an appropriate basis for separating noisy signal from the image signal. Thresholding is a simple non-linear technique that operates on one wavelet coefficient at a time. In it is almost basic form, each coefficient is threshold by compare with against threshold, if the coefficient is smaller than threshold, set to zero; otherwise it is kept or modified. Since the work of Donoho & Johnstone, there has been much research on finding thresholds, nevertheless few are specifically designed for images.

In this paper, a near optimal threshold estimation technique for image denoising is proposed which is Sub band dependent i.e. the parameters for computing the threshold are estimated from the observed data, one’s set for each Sub band. In introduction part described ultrasound image, frequency filter, thresholding techniques. Section II introduces a classification of denoising techniques. In Section II we quickly review some of the techniques proposed for improved threshold. There are two basic approaches to ovary image denoising, spatial filtering methods and transform domain filtering methods. Section III introduces Simulation Results of ovary image. The Original Image is natural image without any noise. In Section IV we present ovary image simulation result. Conclusions and future scope are presented in Sections V and VI respectively. Used Ultrasound technique in:

A. Ultrasound Images

Ultrasound is an impactful technique for imaging the internal anatomy (e.g., abdomen, breast, liver, kidney, and musculoskeletal). It is relatively inexpensive, noninvasive, harmless for the human body, and portable, but it suffers from a main disadvantage, i.e., contamination by speckle noise. Speckle noise significantly degrades the image quality and complicates diagnostic decisions for discriminating fine details in ultrasound images. Many techniques have been proposed to reduce this noise]. Early methods use various spatial filters such as average, median, and Wiener filter however, each usually do not accurately preserve all the useful information such as anatomical boundaries in the image. Wavelet based image denoising methods are formulated as a Bayesian estimation problem.

B. Frequency Filters

Basic frequency domain filters – low pass, High pass, band pass, and Butterworth filter can be used for despeckling of ultrasound images. However, these basic filters also suffer the same problem as of the basic spatial domain filters, that they also cause important information also disappear along with the speckle. An approach worth mentioning using frequency domain operations is not a simple filter but a pseudo coloring technique. Pseudo coloring is the process of mapping the monochrome image to a 3 dimensional color image by assigning artificial color to each of the Monochrome values based on some static or adaptive criteria. Jakia Afruz et all explain a pseudo coloring based ultrasound image .They explains a special approach by transforming the image and generating the R, G and B components by applying low pass, band pass and high pass filters on the transformed image respectively.

C. Thresholding Technique

Thresholding is a simple non-linear technique that operates on one's wavelet coefficient at a time. In it's in several applications, it may be essential to analyze a given signal. Image processing is signal processing for that the input is an image, such as photographs or frames of video and the output of image processing can be either an image or a set of characteristics or parameters get along to the image. Almost image processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to its original overview. There are applications in image processing that require the analysis to be localized in the spatial domain. The classical way of doing this is through what is called Windowed Fourier Transform. Central idea of windowing is reflected in Short Time Fourier Transform (STFT).The STFT conveys the localized frequency component present in the signal during the short window of time.

The following equation can be used to compute a STFT.

$$\mathrm{STFT}(t, f) = \int [x(t).\, \omega^* (t - t')].\, e^{-j2\pi ft} dt \quad (1)$$

Where x (t) is the signal itself, ω (t) is the window function and * is the complex conjugate.
It is different to the Fourier Transform as it is computed for particular windows in time individually, rather than computing overall time (which can be alternatively thought of as an infinitely large window). The same concept can be extended to a two-dimensional spatial image where the localized frequency components may be determined from the windowed transform. This is one of the bases the conceptual understanding of wavelet transforms. Hence, the main consideration in this thesis will be wavelet technique. The receiving input image with noisy image is filtered with wavelet technique for future processing. The image de-noising is a classical problem in the field of signal or image processing. Additive random noise can easily be removed using simple threshold methods. Denoising of natural images corrupted by noise using wavelet techniques is very effective because of its ability to capture the energy of a signal in few energy transform values.

After applying the wavelet technique noise reduction is applied on the wavelet coefficients at different scales. The motivation for using the wavelet transform is good for energy compaction since the small and large coefficients are more likely attributable to noise and important image features, respectively. The small coefficients can be threshold without affecting the significant features of the image. In its almost basic form, each coefficient is threshold by compare with against a value, called threshold. If the coefficient is smaller than the threshold, it is set to zero; otherwise it is kept either as it is or modified. The inverse wavelet transform on the resultant image leads to reconstruction of the image with essential characteristics. There exist various methods for wavelet thresholding that rely on the choice of a threshold value such as Visu Shrink, Sure Shrink and Bayes Shrink. The Visu Shrink has a limitation of not dealing with minimizing the mean squared error, i.e. it removes too covered images that are overly smoothed. The Sure- Shrink threshold depends upon Stein's Unbiased Risk Estimator (SURE). It minimizes the mean squared error that takes the combination of the universal threshold and the SURE threshold. In this method, the employed thresholding is adaptive, i.e., if the unknown function contains abrupt changes or boundaries in the image, the reconstructed image construct. These methods threshold the empirical wavelet coefficients in groups rather than individually, making simultaneous decisions to retain or to discard all the coefficients within non-overlapping blocks. The proposed method overcomes the limitations of the above mentioned methods. It determines the threshold and neighboring window size for every sub band using its lengths.

The wavelet denoising scheme thresholds the wavelet coefficients, arising from the wavelet transform. The wavelet transform yields a large number of small coefficients and a small number of large coefficients. Simple denoising algorithms that use the wavelet transform consist of three steps.

Step1-: Calculate the wavelet transform of the noisy signal.
Step2-: Modify the noisy wavelet coefficients according to some rule.
Step3-: Compute the inverse transform using the modified coefficients.
The problem of Ovary image denoising can be summarized as follows:

II. CLASSIFICATION OF DENOISING TECHNIQUES

There are two basic approaches to ovary image denoising, spatial filtering methods and transform domain filtering methods.

A. Spatial Filtering

A simple way to remove noise from image data is to employ spatial filters. Spatial filters can be further classified into non-linear and linear filters.

1. Non-Linear: Filters

With non-linear filters, the noise is removed without any attempts to explicitly identify it. In this case, the value of an output pixel is determined by the median of the neighborhood pixels, rather than the mean.
Example- Median filters, Weighted Median.
Advantage of median filter: -
Median is much less sensitive than the mean to extreme values (called outliers); therefore, median filtering is able to remove these outliers without reducing the sharpness of the image. In recent years, a variety of nonlinear median type filters such as
Weighted median, rank conditioned rank selection and relaxed median have been developed.

2. Linear Filters

A mean filter is the optimal linear filter for Gaussian noise in the sense of mean square error. Linear filters too tend to blur sharp edges, destroy lines and other fine image details, and perform poorly in the presence of signal-dependent noise. The wiener filtering method requires the information about the spectrum of the noise and the original signal and it works well only if the underlying signal is smooth. Wiener method implements spatial smoothing and its model complexity control correspond to choosing the window size. To overcome the weakness of the Wiener filtering, Donoho and Johnstone proposed the wavelet based denoising scheme.
Example- Mean filters, Weiner filter

B. Thresholding Function

The selection of thresholding function is the main issue of wavelet threshold denoising.

1) Global threshold function:

One is the hard threshold function:

$$W\hat{}_{j.k} = \begin{cases} W_{j,k}, & |W_{j,k}| \geq \lambda \\ 0, & |W_{j,k}| < \lambda \end{cases} \tag{2}$$

One is the soft-thresholding function:

$$W\hat{}_{j.k} = \begin{cases} \operatorname{sgn}(W_{j,k}).(|W_{j,k}| - \lambda), & |W_{j,k}| \geq \lambda \\ 0, & |W_{j,k}| < \lambda \end{cases} \tag{3}$$

Where sgn(*) is a sign function, $W_{j,k}$ stands for wavelet coefficients, $W\hat{}_{j.k}$ stands for wavelet coefficients after treatment, λ stands for threshold value and it can be expressed as:

$$\lambda = \sigma\sqrt{2\ln(N)} \tag{4}$$

$$\sigma = \mathrm{median}(|c|)/0.6745 \tag{5}$$

Where N is the image size, σ is the standard deviation of the additive noise and c is the detail coefficient of wavelet transform. The soft-thresholding rule is chosen over hard-thresholding, for the soft-thresholding method yields more visually pleasant images over hard thresholding.

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2) Penalized Threshold Function

In this, the value of threshold is obtained by a wavelet coefficients selection rule using a penalization method provided by Birge-Massart.
MATLAB code for Penalized Threshold

$$\mathrm{THR} = \mathrm{wbmpen}(\mathrm{C}, \mathrm{L}, \sigma, \alpha) \qquad (6)$$

Where [C, L] is the wavelet decomposition structure of the signal or image to be de-noised SIGMA is the standard deviation of the zero mean Gaussian white noise in de-noising model
ALPHA (α) is a tuning parameter for the penalty term. It must be a real number greater than 1. The scarcity of the wavelet representation of the de-noised signal or image grows with ALPHA. Typically ALPHA = 2

3) Proposed Threshold Method

A major problem to find an optimized value for threshold .A small change in optimum threshold value destroys some important image details that may cause blur and artifacts. So, optimum threshold value should be found out, which is adaptive to different sub band characteristics. Here we proposed a new threshold estimation technique which gives an efficient threshold value for salt & pepper noise to get high value of PSNR as compared to previously explained methods.
For salt & pepper noise it is given by

$$\lambda_{\text{proposed}} = \lambda + 2\beta \qquad (7)$$

Where, λ = global threshold value and it is given by

$$\lambda = \sigma\sqrt{2}\ln(\mathrm{N}) \qquad (8)$$

and β = penalized threshold value.

III. SIMULATION RESULTS OF OVARY IMAGE

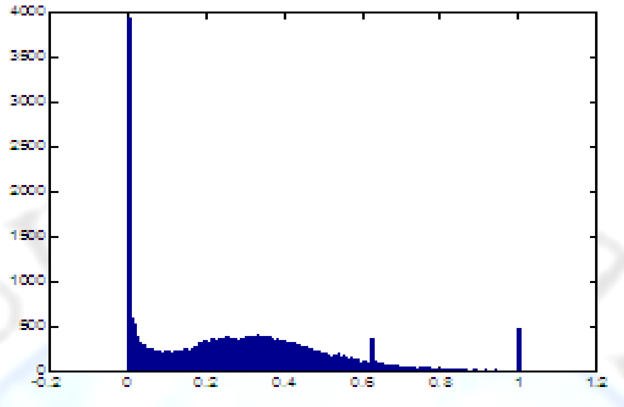
1. The Original Image is natural image without any noise.

2. Mask image

3. Threshold

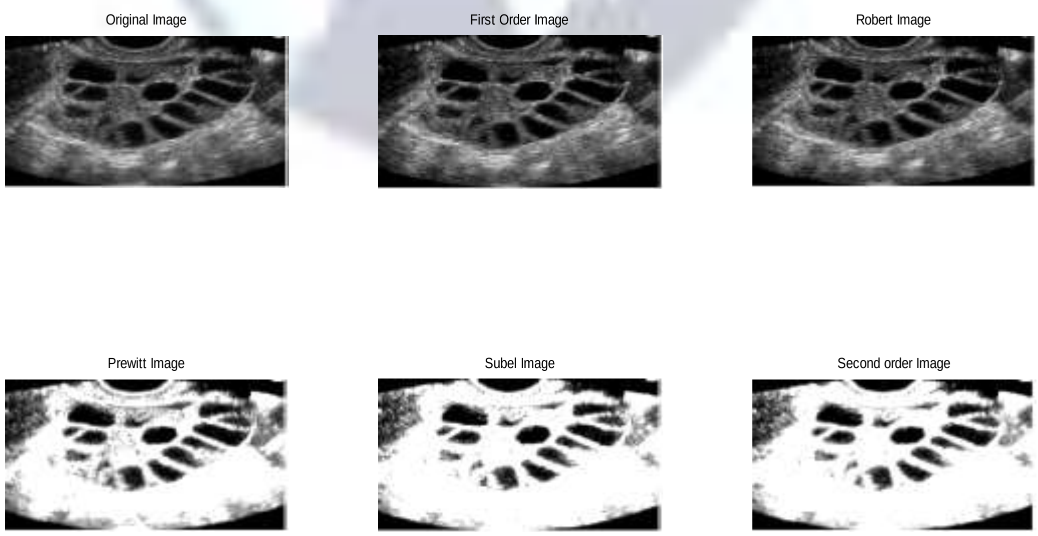
4. Image negative

5. Histogram



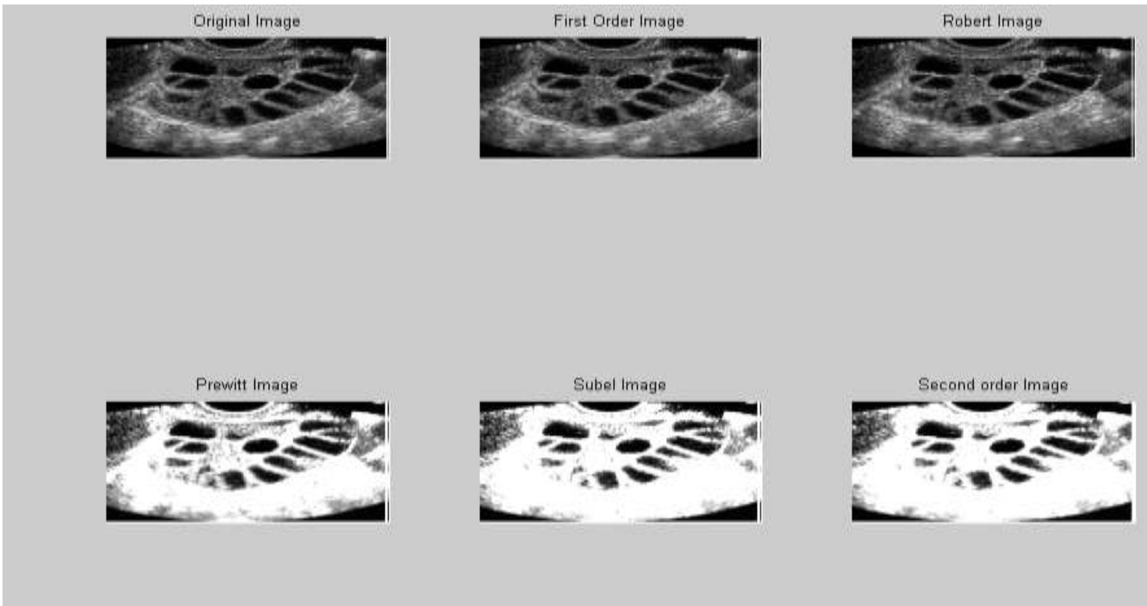
6. Enhancement Image

7. Edge Detection



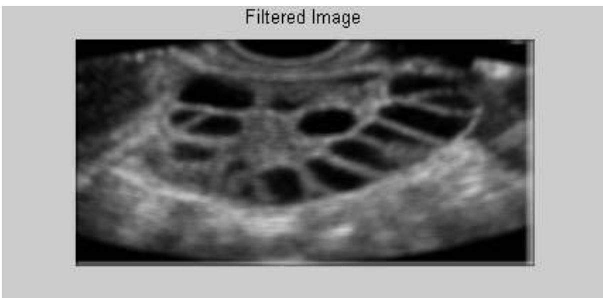
8. Enhancement Image

9. Edge Detection

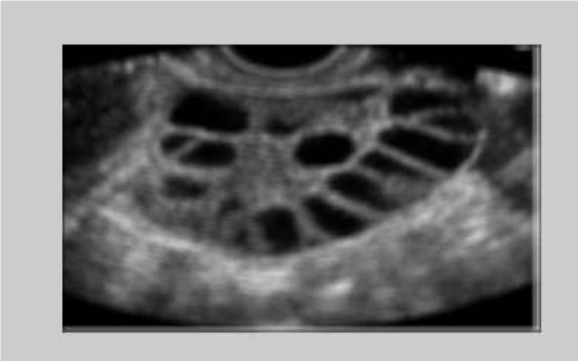


10. Regularized filter

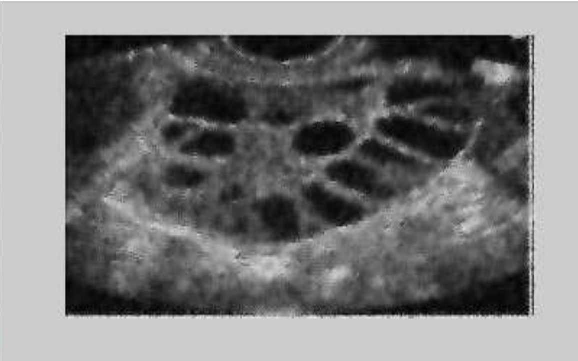
11. Imfilter



12. Multi-dimensional filter

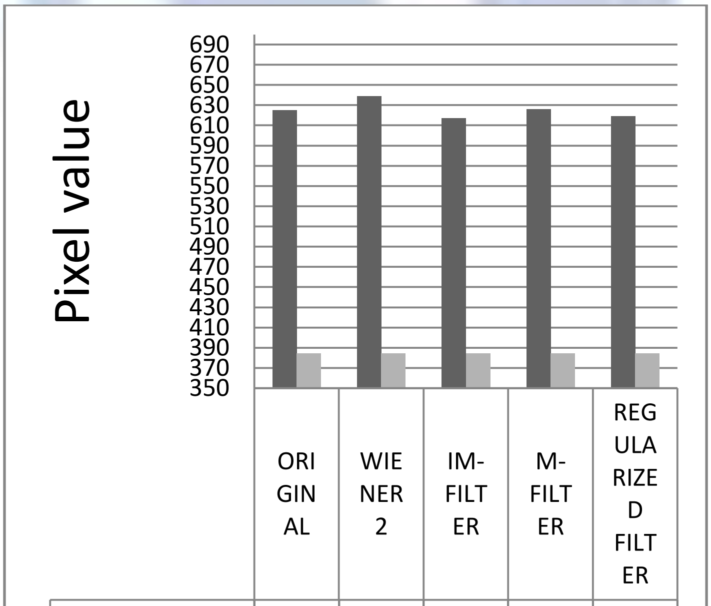


13. Wiener filter



IV. COMPARISON GRAPH

The table shown below states that wiener filter's image contains more pixel horizontal value as compared to other filters like IM-filter and multi dimensional filter. So from the details given in the table, it is clear that Wiener filter is chosen for the best results for any image processing method.



	ORIGINAL	WIENER 2	IM-FILTER	M-FILTER	REGULARIZED FILTER
pixel horizontal width	625	639	617	626	619
pixel vertical width	384	384	384	384	384

V. CONCLUSION

In this paper, we have proposed a new threshold estimation technique in which an ovary image in 'jpg' format is injected salt & pepper noise. Further, the noised image is denoised by using different filtering and denoising techniques. From the results (figure 1 to figure 8) we conclude that:

The proposed threshold mentioned in this paper shows better performance over other techniques. Thus we say that the proposed threshold find applications in image recognition system, image compression, medical ultrasounds and a host of other applications.

VI. FUTURE SCOPE

The field of image processing has been growing at a very pace. The day to day emerging technology requires more and more revolution and evolution in the image processing field. The well known saying" A picture says a thousand words" can be taken as the main motive behind the need of image processing. The work proposed in this thesis also portrays a small contribution in this regard. This work can be further enhanced to denoised the other type as well, like RGB, indexed, binary images. It provides a good on to the already existing denoising technique can provide a good platform for further research work this respect.

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