

A Comparative Study on Speckle Reduction Techniques in Medical Ultrasound Images

Gokilavani Chinnasamy, Gowtham M

Abstract- In medical image processing, image denoising has become a crucial task. Medical Ultrasound images are widely used but are easily affected by speckle noise. Denoising of speckle affected images is necessary for proper diagnosis. Speckles can be reduced by various spatial and frequency domain filtering techniques. Many other techniques are also proposed in the literature. This paper compares three such speckle reduction techniques and they use anisotropic diffusion, logarithmic contourlet based and wavelet based thresholding technique. Wavelet is the emerging technique and is proved to be better in terms of quality measured via the performance evaluation criteria such as PSNR (Peak signal to noise ratio), MSE (Mean Square Error) and so on.

Index Terms- Anisotropic diffusion, Contourlet, Image denoising, PSNR, MSE, Spatial & Frequency filtering, Speckle noise, Wavelet.

1 INTRODUCTION

Image processing is the field of science that deals with processing of raw images. The processed images may be corrupted by various types of noises arising from acquisition of an image by means of a device. Image restoration attempts to remove such noises and restores back the original image, which is needed for several types of application [1].

Images are classified into various categories such as medical images, satellite images and astronomical images. All these images are easily prone to noise by various factors. There are many types of medical images such as MRI (Magnetic Resonance Imaging) images, CT (Computed Tomography) image and ultrasound images. MRI images are best suited for soft tissues in our body such as brain and muscles but it is not suited for imaging of bone structures. CT images suits for harder parts such as bones but they did not suit for brain and other muscular structures. Ultrasound images on the other hand are used for soft tissues and imaging of organs such as liver, kidney, uterus, spleen, heart and brain. Also MRI and CT use ionizing radiation which is harmful to the patients and are costly. But, ultrasound images are free from ionizing radiations and are less costly, portable, less or no side effects and provides live images.

Ultrasound images are formed by passing sound waves inside the body. When the sound waves are passed, the back scattered coherent waves with different phases undergo constructive and destructive interference in a random manner and as a result, the finally formed image is corrupted by a random granular pattern called "speckle". A speckle form the high frequency content of the image and it degrades the visual quality of the image. This paper compares three such speckle reduction techniques.



Fig1. Ultrasound image of kidney.

Fig1. Shows the ultrasound image of a kidney which is affected by the speckle noise.

This paper is organized as follows. Chapter two deals with background review. In chapter three mathematical formulations are discussed. Chapter four deals with speckle reduction using anisotropic diffusion. Speckle reduction using logarithmic contourlet is discussed in the fifth chapter. Chapter six deals with speckle reduction using wavelet based thresholding. Performance evaluation metrics is given in the seventh chapter whereas conclusion is given in the eighth chapter.

- Gokilavani Chinnasamy is currently pursuing M.E (ECE) in SNS College of Technology, Coimbatore-641035, India.
Email:vanichinnasamyso@gmail.com
- Gowtham M is currently pursuing M.E(ECE) in SNS College of Technology, Coimbatore-641 03, India
PH:+91 7373551144. Email:1555gowthamm@gmail.com

2 BACKGROUND REVIEW

Speckle noise greatly affects ultrasound images. The interesting thing about speckle noise is that it is multiplicative in nature whereas other noises such as Gaussian noise, salt and pepper noise and Brownian noise are additive in nature. Speckle noise is granular in nature and it increases the mean grey level of local area and this causes difficulty in image interpretation. It is easy to remove additive noise wherein the removal of multiplicative noise requires some additional efforts.

Multiple look processing is one of the methods to remove speckle noise. Adaptive and non adaptive filters are also proposed in the literature. Adaptive filters adapt the weights according to the local texture information across the noisy image. Some examples of adaptive filter include kuan filter, lee filter, frost filter and RGMAP (Refined Gamma Maximum A Posteriori) filter. Non adaptive filters apply same weights uniformly across the entire image. Mean and median filters are the examples of non adaptive filters in which the median filter better preserves the edges than a mean filter.

In [2], a speckle reduction technique is divided into two categories. The first technique recovers the image by summing more than few observations of the same image. The second technique uses wiener filtering, which is specially designed for additive noise. So we are using homomorphic approach in which multiplicative noise is converted into additive noise by means of logarithmic transformation.

3 MATHEMATICAL FORMULATIONS

Speckle affected image can be modeled as,

$$Y(x,y)=S(x,y).N(x,y) \quad (1)$$

Where $Y(x,y)$ is the noisy image, $S(x,y)$ is the noise free image and $N(x,y)$ is the speckle noise which is multiplicative in nature. All noise removal techniques mainly aims at removing the noise $N(x,y)$ and restoring the noise free image $S(x,y)$. Also the tradeoff between noise removal and holding image information must be considered. To change the multiplicative noise into additive one, logarithmic transformation is applied to (1).

$$\text{Log}[Y(x,y)=S(x,y).N(x,y)] \quad (2)$$

$$Y'(x,y)=S'(x,y).N'(x,y) \quad (3)$$

Where $Y'(x,y)$, $S'(x,y)$ and $N'(x,y)$ represents the logarithmic form of noisy image, noise free image and speckle noise respectively. Using (3), filters can be applied easily to remove speckle noise.

4 SPECKLE REDUCTION USING ANISOTROPIC DIFFUSION

In [3], a speckle reduction technique was proposed for 3D ultrasound images. Anisotropic diffusion can be applied to both 3D as well as 2D images. This is done in both continuous and discrete domain. This takes into account the 3D information since this 3D preserves the edges and smoothness of the homogenous regions. The limitation of this work is that, while quantifying the structures of interest in the body we can obtain only the 2D frame of the image. 2D frames are not that much efficient to know the progress of the medical treatment and tracking of diseases.

5 SPECKLE REDUCTION BASED ON LOGARITHMIC CONTOURLET

In [4], speckle noise is removed based on logarithmic contourlet transform. Here noise model is constructed and it is transformed into additive one. Then, DWT (Discrete Wavelet transform) of the noisy image is calculated followed by the calculation of variance of noise and then the weighted variance of the signal. Then the threshold value of all the pixels in the sub-band coefficients and then IDWT (Inverse Discrete Wavelet transform) is calculated. Finally PSNR is used as evaluation metric. Here the local variance and mean of the speckle has a linear relationship with the image. If the pixel is not within the ratio of local variance to mean, then it is not considered to be in homogenous region and cannot be smoothened.

6 SPECKLE REDUCTION BY SUITABLE THRESHOLD USING WAVELET

In [5], a thresholding procedure is proposed for reducing speckles. This includes a data driven exponential operator that operates on wavelet coefficients. Generally for denoising the noisy images, the wavelet coefficients are passed through threshold testing. Threshold testing replaces the noisy coefficients below the fixed value with zeros and the remaining coefficients are kept same and they are used to reconstruct the original image. The thresholding operator proposed here depends upon noise level and signal characteristics at different scales. Here speckle is assumed as a fine grain structure. Here at first, the forward wavelet transform of the noisy image is computed and then the coefficients are filtered by thresholding operator. Inverse wavelet transform is performed on filtered coefficients, which are useful for image reconstruction. This algorithm removes the speckle noise to a great extent since this uses a modified thresholding using exponential operator.

7 PERFORMANCE EVALUATION CRITERIA

The denoised image which is recovered from speckle noise can be analyzed by various performance metrics as given

below from equations () to (). The MSE (Mean Square Error) is given by the equation,

$$MSE = (1/MN) \sum \sum [X(i,j) - Y(I,j)]^2 \quad (4)$$

The PSNR (Peal Signal to Noise Ratio) is given by the equation,

$$PSNR = 10 \log_{10} (2\pi^2/MSE) \quad (5)$$

8 CONCLUSION

Wavelet transform is the emerging technique in the field of image processing especially in image restoration and denoising. In this paper three techniques are discussed. On comparing these three techniques, wavelet based approach sounds good in reducing speckle noise in medical ultrasound images. Wavelet based approach is based on multi-resolution analysis and it preserves the edge details and features of the image when compared to the other techniques proposed in the literature. And also wavelet based approach left the low resolution coefficients unaltered.

REFERENCES

- [1] "Research And Application Of Image Denoising Method Based On Curvelet Transform" JIANG Taoa, ZHAO Xinb, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B2. Beijing 2008
- [2] International Journal of Computer Theory and Engineering, Vol. 1, No. 1, April 2009, 1793-8201 "Speckle Noise Reduction in Ultrasound Images by Wavelet Thresholding based on Weighted Variance", S.Sudha, G.R.Suresh and R.Sukanesh
- [3] Computerized Medical Imaging and Graphics 28 (2004) 461-470, Elsevier "Speckle reducing anisotropic diffusion for 3D ultrasound images", Qingling Sun, John A. Hossack, Jinshan Tang, Scott T. Acton.
- [4] "A Logarithmic Threshold Contourlet Based Method for Speckle Noise Reduction of Medical Ultrasound Images" Amit Kumar Gupta, Asst. Professor of Computer Science Chitransh A.D.P.G College Bhopal (M.P).
- [5] Ieee Transactions On Instrumentation And Measurement, Vol. 62, No. 8, August 2013 "A Suitable Threshold For Speckle Reduction In Ultrasound Images" Gregorio Andria, Member, Ieee, Filippo Attivissimo, Member, Ieee, Anna M. L. Lanzolla, Member, Ieee, And Mario Savino, Member, Ieee.

AUTHOR'S BIBILIOGRAPHY



Gokilavani Chinnasamy was born in Tami Nadu, India on 1991. She completed her B.E., degree in Electronics and Communication Engineering in Hindusthan College of Engineering and Technology, Coimbatore. And currently pursuing her M.E., degree Specialized in Electronics and Communication Engineering in SNS College of Technology, Coimbatore. Her area of interest includes Digital Image segmentation, Image enhancement and Image restoration. She has published papers in various international journals. She is a member of IETE and the IRED.



Gowtham M was born in Tami Nadu, India on 1989. He completed his B.E., degree in Electronics and Communication Engineering in SNS College of Technology, Coimbatore. And currently pursuing his M.E., degree Specialized in Electronics and Communication Engineering in SNS College of Technology, Coimbatore. His area of interest includes Image enhancement and Image compression. He has published papers in various international journals He is the member of the IRED.

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