# Wavelet Based Echocardiography Image Denoising

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*Abstract*: - In this paper we study the effects of some image denoising methods that were developed in the last years on the echocardiography image. All algorithms are done in wavelet domain because wavelet had shown is a very powerful tool in image denoising. We use these algorithms such as wiener filter, hard theresholding and soft theresholding in wavelet domain. Many experiments are done on wide variety of echo image. The results are shown the wiener filter is superior than other methods in this case.

*Keyword*: Echocardiography, Wiener filter, Image denoising

## 1. Introduction

Medical image processing is one of the most important area in image processing. In this field many research were done on medical image denoising. Because the essential tools for diagnosing of many illness is images got from especial part of body. With the wide spread use of digital imaging in medicine application, the quality of these images becomes very important issue. For achieving the best result in diagnosing decease, medical image must have good quality and without noise and artifact. But all medical image have visual noise which come from variety of sources such as acquisition, transmission storage and display devices. Also the type of reconstruction and enhancement algorithm create noise in medical images. With improvement in technologies used in acquiring digital medical images, the noise has not been removed completely. In the other hand, noise reduction remains one of the major challenges in the study of medical imaging and no imaging method is free of it. But noise is prevalent in some types of image. For example noise is very important in ultrasound imaging, magnetic resonance imaging (MRI) and computer tomography (CT). Noise in these images could cover and blur important features. Therefore image denoising techniques are used to make the most important features more easily visible. In all denoising methods it is necessary to Retain as much as possible the important signal features. Wavelet transform is one of the most popular tools in denoising. In the recent year many researches are done on wavelet thresholding and threshold selection for signal denoising [1],[2],[3]. The basic principle of wavelet thresholding is to identify and zero down wavelet coefficient of a signal which contain mostly noise. The idea in wavelet thresholding is that by performing a wavelet transform of a noisy image, random noise will be represented principally as small coefficient in the high frequencies or equivalently the small coefficients belong to noise and large coefficient belong to original signal [4]. Therefore by setting small coefficient to zero it seems the most of the noise will be removed. In the wavelet hard thresholding technique after applying wavelet transform, each coefficient is compared with a threshold value. If the coefficient is smaller than threshold, set to zero, else it is preserved. After inverse wavelet transform, the reconstructed image have less noise. But finding best threshold value is very important in this algorithm. Soft thresholding is another method used in many applications. This paper is organized as follows: in section 2 some image denoising methods in wavelet domain such as thresholding and wiener filtering are introduced. Experimental result on some image data by different variance noise and discussion about performance of algorithms are presented in section 3. In the last section the conclusion is given.

## 2. Image denoising based wavelet

One of the popular tools for image denoising is wavelet transform. Many algorithms in this domain were discussed but these methods have their own problems. Wavelet thresholding [1] is one of the most important schemes, which is used in image denoising application. This method first performs wavelet transform of a noisy image. Random noise is represented as small coefficient in the high frequencies. Therefore a thresholding by setting this small coefficient to zero will remove much of the noise in the image. For example wavelet hard thresholding scheme, that sets wavelet coefficient below certain value to zero. This method is easy for implementation and if uses reasonable threshold value will be effective method. But using this method introduces artifacts that influences the diagnosing procedure and makes the hard thresholding scheme don't be the adequate choice in medial image denoising. An improvement in wavelet thresholding is soft thresholding [5]. In this method the artifact reduces effectively but doesn't remove completely. For implementation, first k level decomposition is performed. Then threshold value for each subband (except the lowpass residual) is calculated. Then thresholding is applied to the noisy coefficient. In the next step the inverse wavelet transform is perform to reconstruct the denoised image. For achieving to threshold value, the noise variance must be estimated. More details are discussed in [7]. Third method is wiener filtering. Wiener filter or Least Mean Square filter is defined by the following expression: (1)

$$F(u,v) = \left[ \frac{H(u,v)^*}{|H(u,v)|^2 + [Sn(u,v)/Sf(u,v)]} \right] G(u,v)$$

$G(u,v)$ and $H(u,v)$ are degraded image and degradation function respectively. $Sn$ And $Sf$ are the power spectra of noise and original image (before Adding of noise). The wiener filter assumes the noise and power spectra of the object a prior [6].

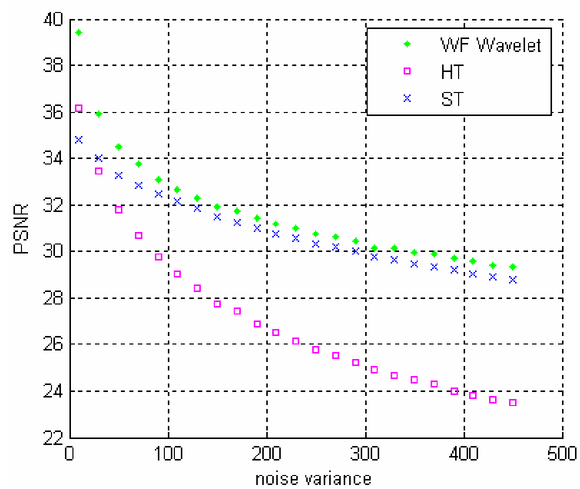



Fig.1: PSNR of recovered image versus noise variance for image of Fig.3(a)

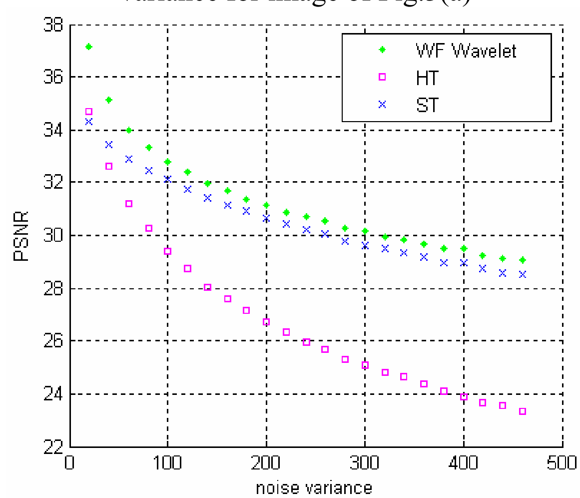
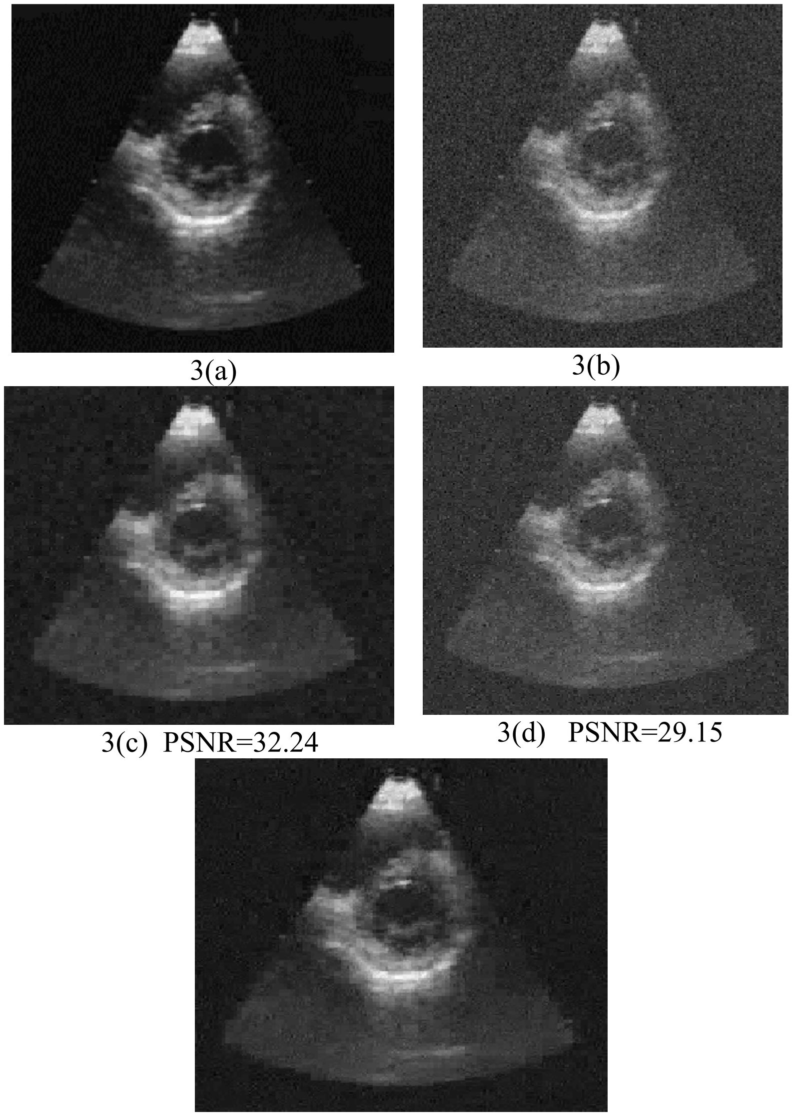



Fig.2: PSNR of recovered image versus noise variance for image of Fig.4(a)

## 3.Implementation and experimental result

In this section we provide some example to show the performance of three mentioned algorithms. All images size are $256 \times 256$ that acquired from echocardiograph instrument. Artificial Gaussian noise is added to these images as shown in Fig.3 (b) and Fig.4 (b). We used har wavelet in matlab toolbox. Also 5 levels decomposition are performed to the image. The PSNR is employed to determine the quality of recover images for each algorithm. The results are shown in Fig.1 and Fig.2 for two different images. The x axis is variance of Gaussian



3(a) 3(b)

3(c) PSNR=32.24 3(d) PSNR=29.15

3(e) PSNR=32.73

Fig.3: (a) original image, (b) noisy image, (c) Denoised by soft thresholding, (d) Denoised by hard thresholding, (e) Denoised by wiener filter

Noise and y axis shows the PSNR of the reconstructed image. The PSNR is defined by following equation:

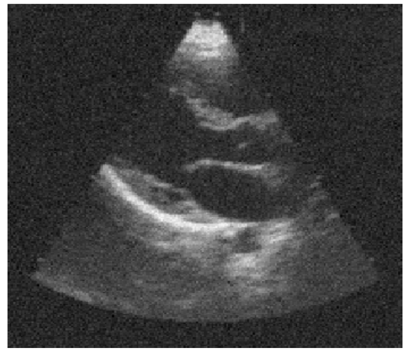
$$PSNR = 10\log_{10}\left(\frac{255^2}{\frac{1}{N}\sum_{i=1}^{N}(f_i - f_i^*)^2}\right) \qquad (2)$$

The Fig.1 and 2 shows the PSNR is better in wiener filtering method than two other methods for all variances and both images. Also the quality of image recovered by soft thresholding is better than hard thresholding. As you seen the quality in recovered image by hard thresholding is very poor when the noise variance is significant, but in lower variance all three methods have the same performance approximately. To could compare the performance of different algorithm some results are shown in Fig. 3 and Fig.4.

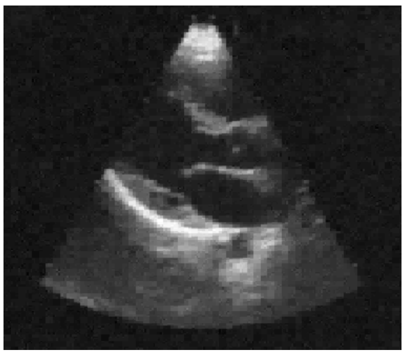
## 4. Conclusion

All medical images have visual noise but in some of them for example echocardiography image this effect is more. In this paper we use some popular

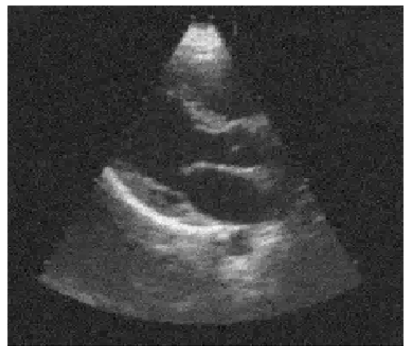
4(a)



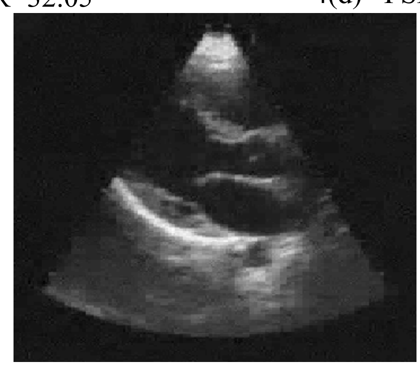
4(b)



4(c) PSNR=32.05



4(d) PSNR=29.45



4(e) PSNR=32.85

Fig.4: (a) original image, (b) noisy image, (c) Denoised by soft thresholding, (d) Denoised by hard thresholding, (e) Denoised by wiener filter

image denoising algorithm in wavelet domain such as wavelet thresholing and wiener filter. These algorithms applied on several echocardiography image with different noise variance. The results show the wiener filter is superior to the both thresholding methods. Also the performance of soft thresholding method is better than hard thresholding. The difference between two methods is seen easily when the noise variance increase. For example when variance is more than 400, the difference between PSNR is at least 5db while this difference between wiener filter and soft thresholding is the less than 1db. Therefore it is suggested that the hard thresholding isn't fair method for denoising these medical images. In the future work we want to use fractal-wavelet algorithm for denoising and compare it by mentioned methods.

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