Denoising of Lung Sound Using Wavelet Transform

Vishnubhatla N V L N G Sharma, Sharmila A., Rajini, G.K.
School of Electrical Engineering, VIT University
Vellore, India

***Abstract* - Noise is the unwanted background accompanied with the lung sound. The main focus of this paper is denoising of lung sound to improve the diagnosis of respiratory problems. The major source of noise is heart. In this paper we considered normal heart sound (S1&S2), which occupies wide bandwidth with lung sound. A lot of research work has been done on denoising. Here we have used wavelet as denoising tool which performs noise reduction for 1D signals by using the discrete wavelet transform (DWT).**

***Keywords* - Discrete wavelet transform, noise reduction**

I. INTRODUCTION

The wavelet transform has become a powerful tool for signal analysis and is widely used in many applications which include signal detection and denoising. Denoising is a process which we reconstruct a signal from a noisy one. We want to find threshold value that will use to remove noise from noisy signal to recover the original signal efficiently. In time domain signal, the independent variable is the amplitude. Most of the information is hidden in the frequency content. By using Wavelet Transform, we can get the frequency information which is not possible by working in time domain. The analysis of a non-stationary signal using the Fourier Transform and Short Time Fourier Ttransform does not yield satisfactory results. Better results can be obtained using wavelet transform analysis. Wavelet analysis is able to express signal appearance that other analysis techniques miss such as break points, discontinuities etc.

II. WAVELET TRANSFORM

Wavelet techniques are, conversely, a more modern approach to noise reduction, although their origin lies in the timeless methods developed by Fourier. Wavelet analysis decomposes the signal into a family of basic functions and provides two significant advantages over the traditional Fourier analysis [1]. First in wavelet analysis there is a wide variety of basic functions like biorthognality etc to choose from, and second, a multi-resolution capability is provided in the time frequency domain which is critical to the identification and elimination of noise in a non-stationary environment. Wavelet techniques have proven to be a viable tool for the denosing of acoustic signals. Wavelet transform has been intensively used in various fields of signal processing. It has the advantage of using variable size time windows for different frequency bands. This results in a high frequency resolution in low bands and low frequency resolution in high bands. Moreover, when one is restricted to use only one (noisy) signal (as in single microphone speech enhancement), generally the use of the subband processing can result in a better performance. Therefore, wavelet transform can provide an appropriate model for speech signal denoising applications. The DWT is considerably easier to implement without needing to perform numerical integration as like Continous wavelet transform(CWT).

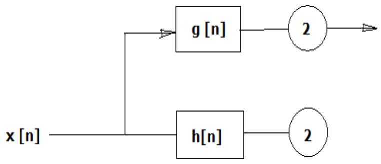
Discrete wavelet transform

The simplest way to define the discrete wavelet transforms (DWT) is to describe the computational structure used to calculate it. The DWT is most easily computed by an iterated filter bank; imposing specific conditions on the filters yields a wavelet transform, imposing further conditions determines the properties of that transform, such as orthogonality and frequency selectivity. As a precursor to the discrete wavelet transform, consider the two-channel filter bank depicted in Figure 2.1. The left half is denoted the analysis filter bank, and correspondingly, the right the synthesis filter bank. In the analysis filter bank, the input x is passed through two filters h0 and h1 and both filter outputs are down sampled by a factor of 2 producing the two outputs X0 and X1. The synthesis filter bank recombines X0 and X1 by unsampling each of these by 2, filtering respectively by g0 and g1, and then summing. This final output is designated ^x[2]. For this structure to be of any interest, the filters h0 and h1 must be different frequency selectivity.The upper branch h0 is arbitrarily selected as having the lower passband of the two. Under certain conditions on the filters, the output ^x equals the input x for every input. The transform from x to (X0,X1) can then be inverted. Specifically, the synthesis filter bank inverts analysis filter bank. The analysis-synthesis pair is then called a perfect reconstruction filter bank. These filter restrictions can be expressed in many forms, but time- and z-domain representations are the most transparent and useful for this work.

- S of the branches
  $G0H0(z) + G1(z)H1(z) = 2$
  $G0H0(-z) + G1(z)H1(-z) = 0$
- Time-domain: For i, j = 0, 1, the convolution of the impulse responses of the filters satisfy
  $(hi*gj)[2n] = \delta[i-j]\delta[n]$

where δ[m] is the delta function: δ[m] =1 for m = 0 and δ[m]=0 for all m6 = 0. With the convention above of h0 being a low-pass filter, in a perfect reconstruction filter bank, g0 must be a low-pass filter also, and h1 and g1 are forced to be high-pass. Discrete wavelet transforms are generated via cascaded applications of the analysis filter bank. The output of the analysis low-pass filter is the input into another two-channel analysis bank.

A J-stage wavelet transform can be produced with J such analysis banks interating on the low-pass branches as shown. The final output consist of the outputs of the final stage low-pass filter and each of the J high-pass filter outputs. The outputs of the branches are called subbands. For J-stage filter, there are J+1 subband outputs, which will be denoted X0,…,XJ. The coefficients of the subband, X0 , resulting from the J successive low-pass filter tags are called the scaling coefficients. The coefficients in the other J subbands,X1,…,XJ, are called detail coefficients.



III.DENOISING ALGORITHM

Wavelet denoising process

The denoising algorithm is given as follows:

1. Decompositon - Choose a wavelet, and choose a level N. Compute the wavelet decomposition of the signal s at level N.
2. Detail coefficients thresholding - For each level from 1 to N, select a threshold and apply soft thresholding to the detail coefficients.
3. Reconstruction - Compute wavelet reconstruction based on the original approximation coefficients of level N and the modified detail coefficients of levels from 1 to N.

Thresholding

Thresholding in wavelet will eliminate unwanted coefficients by fixing a threshold value . By eliminating these coefficients signal can increase the SNR value. Donoho introduced two kinds of thresholding hard and soft thresholding.[4]

Threshold value estimation

In denoising method while denoising a signal threshold value should be fixed for eliminating the noise. This threshold value is generated from any of the functions namely ‘rigrsure’, ‘heursure’, sqtwolog’, ‘minimaxi’ and universal.

Proposed threshold equation

One new threshold value is been fixed by the following equation

$$\lambda = \sigma_n \sqrt{2log2(N)}$$

where N denotes number of samples of noise. Again Universal threshold was proposed in [2] and choose rescaling method single level with 3 level transform of wavelet db05 .Here n denotes number of level of transform.

In DWT analysis, the method is entirely different. The idea in this case is based on the assumption that the amplitude, rather than the location, of the spectra of the signal to be as different as possible for that of the noise. This allows clipping, and shrinking of the amplitude of the coefficients to separate signals or remove noise. It is the localizing or concentrating properties of the wavelet transform that makes it particularly effective.

Image enhancement in wavelet denoise filter is utmost important to improve the quality of image for human or machine interpretability. However such attempts can be heuristic and problem oriented. Wavelet filters performs reconstruction of image which may lead the image to the degradation. But still it is a powerful tool in noise cancelltion where series of filters are recursively applied and specific conditions like frequeny selectivity is imposed to get signal.

IV. RESULTS AND CONCLUSION

Thus the proposed system is implemented with DWT. The wavelet transform level 3 and wavelet choosed is ‘db05’ selected, which gives better results than other transform level. The final output is given below. This the output graph obtained by denoising the given signal.The new wavelet threshold estimation and transform settings has been developed and applied for the given signal. By comparing the original and denoised signal response the proposed system presents the two as exact replica of each other.

The figures shows different level of decomposition. In hard threshold the signal below the threshold value assigned zero and the signal above threshold value retained. In soft threshold the signal below threshold assigned zero. If the signal above threshold then the values are replaced by (x – λ). If the signal value is below the threshold value it is replaced by (x + λ).

The output signal figure 3 along with the input is presented in figures. In the figure1 lung sound wave is plotted as original signal. The next wave is the heart noise signal. signal is used as input to be denoised. DWT is applied to this noisy signal and after decomposing the signal using wavelet thresholding, the inverse wavelet transform is applied to reconstruct the original signal. From figures4 and 5 it is clear that soft threshold function performs better than the hard threshold function.

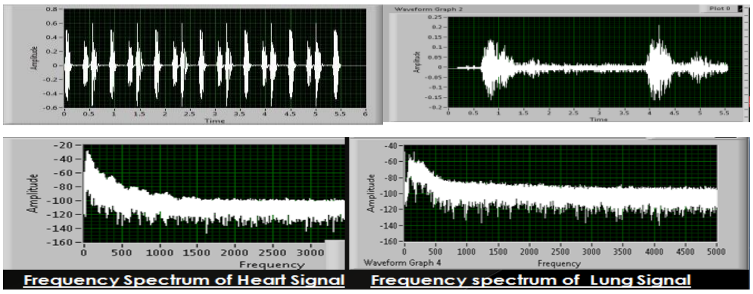


Fig.1 Waveform graphs and Frequency spectrum

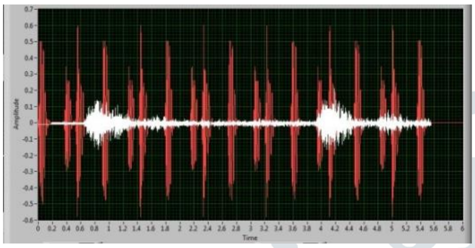


Fig.2Convolution of Signals

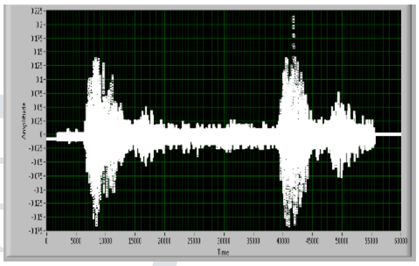


Fig.3 Output of denoised signal

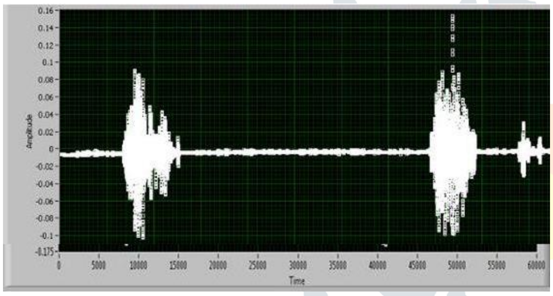


Fig4 Output of Hard thresholding

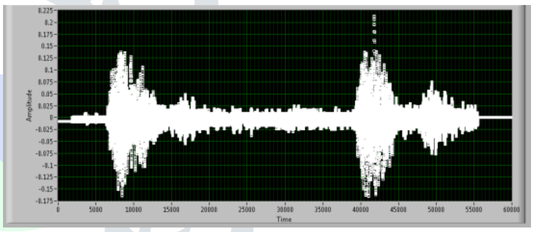


Fig.5 Output of Soft thresolding

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