DENOISING OF ECG BY WIENERSHRINK IN THE WAVELET PACKET DECOMPOSITION

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ABSTRACT

We present Redundancy Wavelet Packet Decomposition (RWPD) method used to ECG signal denoising process. Signal decomposition is performed by library of wavelet Daubechies filters in full decomposition tree. In denoising process (modification of decomposed wavelet coefficients) is used WienerShrink threshold function and sequentially inverse wavelet transform to signal synthesis.

1 INTRODUCTION

In a clinical environment the ECG signal is usually degrade namely by power line interference, muscle contraction noise (myopotentials) and baseline wandering due to respiration. The trend of our days is enabled automated analysis of ECG signal and practice computational processing. Success of computer analysis mainly depends on relatively noise-free ECG data. There are many methods frequently used to denoising of the ECG signal. Some of them are rather simple with limited utilization some are very complex with many latitude levels. The goal of denoising is to remove the noise while retaining as much as possible the important signal features. Traditionally, this is achieved by linear processing. Most of these methods are very useful and efficient in denoising of narrowband noise where spectral of signal and noise are not conflicting. The filter must be chosen to reflect the trade-off between noise reduction and loss of high-frequency details. In recent years appeared some new methods based on Wavelet Transform (WT) and the results are very encouraged. The denoising methods using the discrete wavelet transform give a noise reduction with only minor change of the ECG waveforms. These good results are due to the advantage of a wavelet filtering over classical linear filtering: time-frequency wavelet decomposition enables the possibility of the noise suppression in the same frequency band of the ECG signal with minimal interference.

2 WAVELET PACKED DECOMPOSITION METHOD

The wavelet packet (WP) method is a generalization of wavelet decomposition that offers a detail signal analysis. Wavelet packets were introduced [1] as a library of orthonormal bases for $L^2(R)$. For a given orthogonal wavelet function, we generate a library of bases called *wavelet packet bases*. Each of these bases offers a particular way of coding of signals, preserving global energy and reconstructing exact features. The wavelet packets bases can be used for numerous expansions of a given signal. The proposed bases library is split into a binary tree configuration (fig 1), in which the nodes represent subspaces with different time-frequency localization characteristics (multiresolution signal decomposition). In first level the library can by represent by structure of appropriate low pass and high pass filters. On higher levels by half-band filters naturally. Wavelet coefficients are the result of the high pass filter applied to the signal or to combinations of low pass filters of the signal. Two levels of Redundancy Wavelet Packet Decomposition Tree is in fig.1

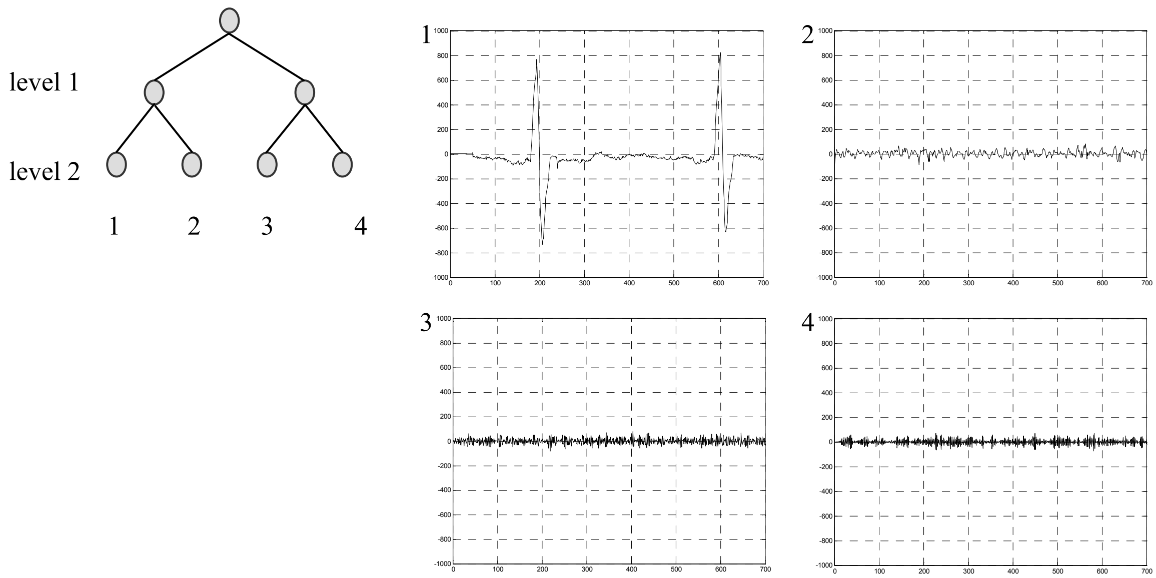

Fig. 1: *Example of 2 levels ECG signal Wavelet Packet Decomposition Tree*

3 WIENERSHRINK FUNCTION

Wavelet noise filters are constructed by calculating the wavelet transform for a signal and then applying an algorithm that determines which wavelet coefficients should be modified. Our approach is represented by thresholding wavelet coefficient in terminal nodes. It is perform by WienerShrink function [2]. In step j is coefficient $y_j(n)$ modified by constant $h_j(n)$,

$$\overline{f_j}(n) = h_j(n) y_j(n) \tag{1}$$

where

$$h_j(n) = \max\left\{\frac{y_j^2(n) - \sigma_w^2}{y_j^2(n)}, 0\right\} = \max\left\{1 - \frac{\sigma_w^2}{y_j^2(n)}, 0\right\}. \tag{2}$$

Constant $h_j(n)$ is modified in every step. Is necessary to evaluate noise standard deviation estimation $(\sigma\ ^2{}_W)$ from the segment between QRS-complexes. Idea of WienerShrink threshold is derived from Wiener filters. So created threshold is simply adapted to signal noise. (fig. 2)

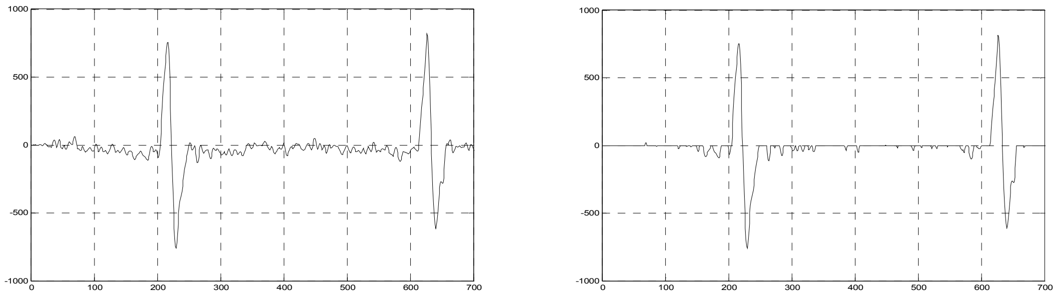

Fig. 2: *WPD coefficients modified by WienerShrink thresholding function*

4 RESULTS

We have tested the signals from CSE (Common standard in Electrocardiography) library (f_s=500). The additive artificial noise with the same spectral properties as the noise in the stress ECG signal was added and the SNR was evaluated after processing.

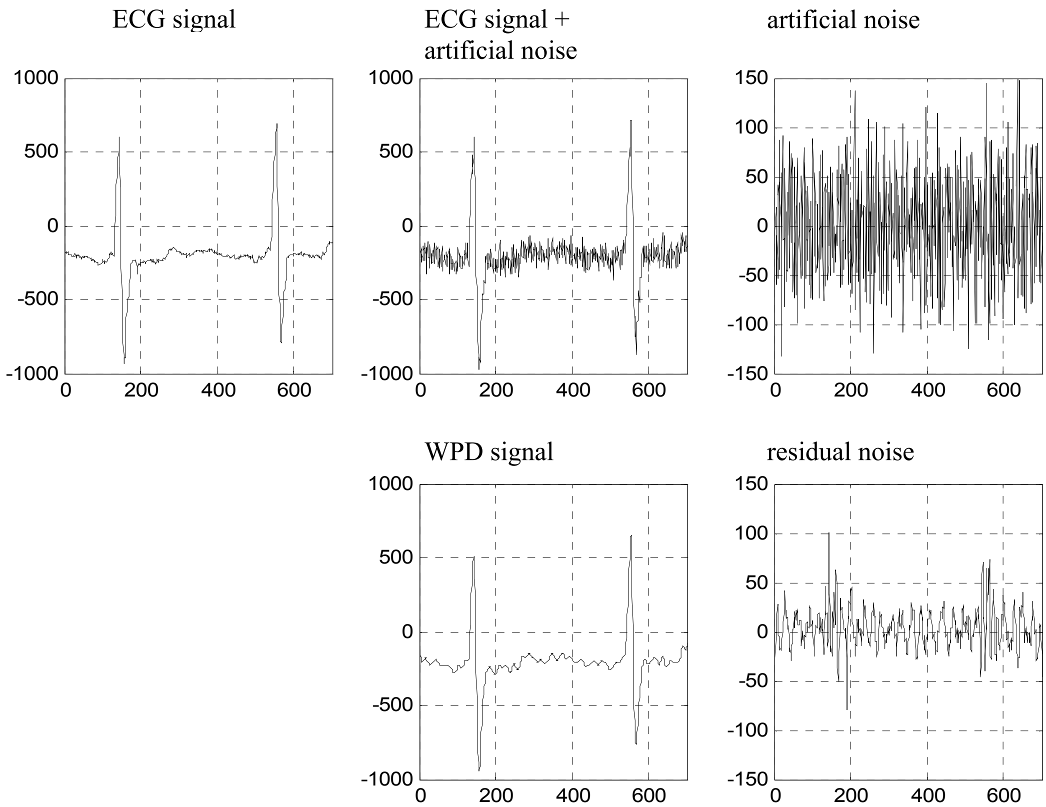

Fig. 3: *Denoising method results*

ACKNOWLEDGEMENTS

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