DENOISING OF ECG BY $\alpha$-TRIM THRESHOLDING OF WAVELET COEFFICIENTS

*S. Poornachandra  
*Dr N. Kumaravel  
K.P. Karthikeyan

*Asst professor, Dept of ECE/ SSN College of Engineering, Anna University, Chennai, India  
#Professor, School of ECE/ Anna University, Chennai, India  
Dept of ECE/ SSN College of Engineering, University of Madras, Chennai, India

*pcmed8@yahoo.com  
#kumaravel_n@annauniv.edu  
kpkar_95@yahoo.com

ABSTRACT

This paper proposes a model for eliminating noise from ECG using $\alpha$-trimmed thresholding. In this paper, the $\alpha$-trimmed thresholding tested in the wavelet based Adaptive Filter Model. The Wavelet co-efficients at every sub-band level is made adapted by LMS algorithm to minimum mean square value and thresholded the adapted coefficients. It is shown that the proposed thresholding method offers variable thresholding to remove redundant wavelet coefficients. The proposed model has considered both thresholding and adaptation for smoothing the signal in the wavelet domain. It finds its applications in noise removal technique, Data compression in telemedicine etc.,

1.1 INTRODUCTION

The adaptive denoising model is to separate signals from the correlated noises [2], [3]. Since the real time ECG signal changes their characteristics with respect to time, the DFT-based Adaptive Filtering doesn’t give time and frequency resolution for time varying signal due to its equal resolution concept [3]. Due to the Multi Resolution Analysis (MRA) characteristic of the Wavelet Transform (WT) [1], the Wavelet Transformed based Adaptive Filtering (WTAF) scheme uses the projection of the input signal onto orthogonal subspace [5],[6].
The paper on soft-thresholding technique, which was proposed in the Donoh’s paper [4] showed remarkable improvements in the signal to noise ratio (SNR) by removing the redundant signal coefficients. In Wavelet based Adaptive filter model, the wavelet coefficients are adapted to its mean-square error, hence denoising is achieved. By introducing both thresholding and adaptation, advantages of both is exploited in the same simulation i.e., by thresholding the wavelet coefficients, redundant values are eliminated and by adaptation, smoothing can be done on the wavelet coefficient. This has achieved better data compression as well as better signal to noise ratio [8], [9], [10].

This paper discusses the concept in three sections. The second section discusses the model, which incorporate the denoising of ECG signal using \( \alpha \)-trimmed thresholding in model. Third section shows the simulation with MATLAB. In the model simulation, Gaussian-noised ECG is made adapted to MSE using LMS algorithm.

### 1.2 \( \alpha \)-TRIM THRESHOLDED BSF-TBA MODEL

The most natural representation of the wavelet transform is

\[
W_\psi f(\tau, s) = \frac{1}{\sqrt{s}} \int_{-\infty}^{\infty} f(t) \psi \left( \frac{t - \tau}{s} \right) dt
\]

\[= \left( f, \psi_{\tau,s} \right)
\]

Where, \( \psi \) = mother wavelet that is well localized both in time and frequency

\( \tau \) = Translation parameter;

\( s \) = scale parameter

The wavelet co-efficient \( C_{jk} \) become

\[
C_{jk} = (W_\psi f)[k/2^j ;1/2^j] \quad (4)
\]

The \((j, k)^{th}\) wavelet co-efficient of \( f(t) \) is given by the integral wavelet transformation of \( f(t) \) evaluated at the dyadic position \( \tau = k/2^j \) with binary dilation factor (scaling factor) \( s = 2^j \) [1].

A \( \alpha \)-trimmed filter [11] is special case of \( L \)-filter. The output \( Y_k \) of the filter for an input signal \( X_k \) is given by

\[
Y_k = \sum_{j=1}^{M} A_j X_{(j)}^k
\]

Where, \( X_{(j)}^k \) is the smallest sample, the \( j^{th} \) order statistic, among the \( M \) samples in the each sub band whose length is \( 2N+1 \).

![Fig(1) mean square error for different values of \( \alpha \)](image)
A particularly simple choice for the $A_j$ coefficients yields an $\alpha$-trimmed filter, with output given by

$$Y_k = \frac{1}{2(N-T)+1} \sum_{j=T+1}^{W-T} X^k_{(j)} \quad (6)$$

Where, $T$ is the largest integer which is less than or equal to $\alpha W$. $0 \leq \alpha \leq 0.5$.

When $\alpha = 0$, the $\alpha$-trimmed filter becomes the running mean filter; When $\alpha = 0.5$, the $\alpha$-trimmed filter becomes the median filter. Major advantage of $\alpha$-trimmed thresholding is variability in the thresholding level. This may be the generalized equation for any thresholding which varies from mean to median filter concept. Depending on the noisy signal’s signal to noise ratio and noise variance, the $\alpha$ value can be set.

In the proposed model, Coif5 WTAF is incorporated and verified the Denoising concept. The fig(3) shows the simulation result of the proposed model. In the simulation, the $\alpha$-trimmed threshold model equally performed compared to the donoh’s median threshold model. The table(1) shows the advantage of $\alpha$-trimmed threshold in the WTAF. The Signal-to-Noise (SNR) of proposed model is superior than the other models given in the table(1). One more advantage of this model is removal of redundant values. This may find its application in data compression.

### 1.4 CONCLUSION

Traditional wavelet-based signal denoising algorithms identify and zero out the wavelet coefficients due to the noise. We specifically address the issue of wavelet selection and the efficient modification of wavelet coefficients by thresholding. Implementation of the new algorithm is simple, results are visually pleasant and comparable to that of state-of-art algorithms.

### 1.3 SIMULATION RESULT

The uniqueness of Wavelet sub-band is multi-resolution. In BSF-TBA model, the wavelet coefficient of noisy signal is are thresholded using $\alpha$-trimmed filter and then coefficients are made adapted to wavelet coefficient of Gaussian noise at every sub-band level.

<table>
<thead>
<tr>
<th>METHODOLOGY</th>
<th>SNR</th>
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<tbody>
<tr>
<td>WT</td>
<td>8.571807</td>
</tr>
<tr>
<td>WTAF</td>
<td>9.122302</td>
</tr>
<tr>
<td>WT with threshold</td>
<td>Donoh’s</td>
</tr>
<tr>
<td></td>
<td>8.913524</td>
</tr>
<tr>
<td></td>
<td>$\alpha$-trimmed</td>
</tr>
<tr>
<td>WTAF with threshold</td>
<td>Donoh’s</td>
</tr>
<tr>
<td></td>
<td>9.063936</td>
</tr>
<tr>
<td></td>
<td>$\alpha$-trimmed</td>
</tr>
</tbody>
</table>

Table(1): SNR of various model
**1.5 REFERENCE**


