Wavelet Transform Based Estimation of 1 Dimensional Signal

Koteswara Rao Mallaparapu, K.V.Ramarao, Shaik Masthan

Abstract: The key idea of this manuscript is denoising of noisy biological signals. For this wavelet thresholding technique is suggested. To eliminate the noise existing in the signal, mixed thresholding function is considered which is the median of Hard, Soft and Garrote functions. The mixed thresholding function is applied by degraded white gaussian noise Electrocardiogram signal. Two methods that are used to calculate the threshold value is FDR technique and Visu shrink technique. The outcomes of mixed functions are compared with remaining functions using Signal to Noise Ratio (SNR) and Mean Square Error (MSE). It is obvious that the mixed function performs superior than remaining functions using Visu shrink technique and performs better than only Hard function using FDR technique.

I. INTRODUCTION

Collecting information increases quickly from last few years. Biological information or signals are also applicable to this. Noise is added to the signal while receiving information. This information will be lost because of the noise present in the signal. Deterioration is essential for these biological signals. Many methods are available to remove the noise. Parametric and non parametric deterioration methods are of two different types. Wavelet transform is commonly used technique in non parametric regression. And wavelet thresholding technique is very popular for regression.

In this work, a mixed thresholding function is suggested. Using global thresholding method and visu shrink method this mixed thresholding function is applied on wavelet factors for denoised biological signal. The results of this function are related by offered hard, soft and garrote functions limits.

II. WAVELET THRESHOLDING

To denoise the signal, wavelet thresholding technique is used. The noisy Electrocardiogram signal is conceded through wavelet transform in this method. A signal into detailed coefficients was decomposed by this method. Using thresholding function, these coefficients are modified. In this function, the threshold value is calculated using thresholding function. These customized detailed coefficients are conceded through inverse wavelet transform. Noiseless ECG signal is obtained by reconstructing the coefficients. For calculating threshold value, global thresholding method, visu shrink method and block JS method are proposed in this paper. For wavelet transform and inverse wavelet transform Coiflet wavelet is preferred.

A. False Discovery Rate method

For one-dimensional data, minimizing false discovery rate technique was introduced by B. Vidakovic. Below a given portion p, it determines the same global threshold for all shrinkage functions by keeping the predictable value of the portion of coefficients inaccurately incorporated in the restoration. Known the M wavelet coefficients (x_m, n = 1, 2... M), initially it calculates x-values

\[ X_n = 2[1- \Phi (|w_n|/\sigma)] \]

Here \( \sigma \) is an estimation of the noise-standard deviation and \( \Phi (\cdot) \) is the cumulative distribution function of the standard normal distribution. Then x outputs are prearranged as \( x(1) \leq x(2) \leq x(3) \ldots \leq x(M) \). Starting with \( n = 1 \), let q be the largest index such that

\[ x_{(q)} \leq q \frac{\sigma}{M} \]

The obtained threshold output is written as

\[ \lambda = \sigma \Phi^{-1} (1 - (x_{(q)}/2)) \]

B. Visu shrink method

Visu Shrink method was developed by donoho and johnstone. This is a universal thresholding method and it is not depending on thresholding function selected. The calculated threshold value is given by

\[ \lambda = \sigma \sqrt{2 log L} \]

where \( L \) is the length of the signal, \( \lambda \) is the threshold value and \( \sigma \) is the standard deviation.

C. Thresholding function

The noisy detailed coefficients are used to modify the thresholding functions. To modify the coefficients, proposed work contains Hard, Soft and garrote thresholding functions. Donoho and Johnstone proposed this hard thresholding function. It can be shown as

\[ H(e, \lambda) = e \text{ for } |e| > \lambda \]

\[ = 0 \text{ else} \]
The simulation.

These detailed coefficients are modified to shrink the soft thresholding function signal and denoised ECG signals used in wavelet transform. By modifying the soft thresholding function, the results are obtained.

\[ M(e, \lambda) = \text{median}(H(e, \lambda) S(e, \lambda) G(e, \lambda)) \text{ for all } |e| > \lambda = 0.2 \times e \text{ else} \]

Where \( \lambda \) is the threshold value and \( e \) represents detailed coefficients

**IV. RESULT AND DISCUSSION**

In the proposed work using hard function, soft function, garrote function and mixed function the results are obtained on noise effected ECG signal are placed. Different noise standard deviation values of ECG are simulated and it is polluted with gaussian noise and the length of the ECG signal is 1024. To decay the noisy ECG signal with detailed coefficients Coiflet wavelet is used in wavelet transform. Using thresholding function these detailed coefficients are modified. The threshold value is fixed using FDR technique, visu shrink technique in thresholding filter. To rebuild the modified detailed coefficients into denoised ECG signal, inverse wavelet transform is used. To compare the results MSE and SNR parameters are used.

\[ \text{MSE} = \frac{1}{t} \sum_{i=1}^{t} (n(i) - \hat{n}(i))^2 \]

\[ \text{SNR} = 10 \log_{10} \frac{\sum_{i=1}^{t} n(i)^2}{\sum_{i=1}^{t} (n(i) - \hat{n}(i))^2} \]

Where \( n(i) \) is original signal, \( t \) represents number of samples and \( \hat{n}(i) \) is denoised signal. After repeating the simulation process for 100 times then take the average values of MSE and SNR. The same results are obtained when this process is performed on different ECG signals. In MATLAB environment this work is implemented. Using existing functions and mixed thresholding function with FDR method and visu shrink method the Mean Square Error and Signal to Noise Ratio values of ECG signal for standard deviation 10, 20 and 30 are shown in Table 1 and Table 2. Using mixed thresholding function with FDR method and visu shrink method the original ECG signal and denoised ECG signals are shown in Figures 3-6. The comparison of Mean Square Error and Signal to Noise Ratio values of FDR method, visu shrink technique are shown in Graph 1-4.

MSE value of 44,3586 and SNR value of 25.9515 are obtained for standard deviation 10. MSE value of 125.2162 and SNR value of 21.4520 are obtained for denoised ECG signal with hard thresholding function. With garrote thresholding function using FDR method For denoised ECG signal with soft thresholding function and MSE is 51.5357 and SNR is 25.3013 are obtained. MSE is 46.6343 and SNR is 25.7345 are obtained in (Table 1) using mixed thresholding function. It is clear that the performance of mixed thresholding function is better than soft and garrote thresholding functions. The performance of standard deviation 20 and 30 is obtained in (Table 1) which will be same. MSE value of 51.8379 and SNR value of 25.2753 are obtained using visu shrink method, for standard deviation 10, for denoised ECG signal with hard thresholding function. MSE value of 190.9958 and SNR value of 19.6114 are obtained for denoised ECG signal with soft...
thresholding function and with garrote thresholding function MSE of 75.1200 and SNR of 23.6654 are obtained. In (Table 2), MSE of 65.5301 and SNR of 24.2576 are obtained. Using mixed thresholding function. From the above results, the performance of mixed thresholding function is better than soft and garrote thresholding functions. The performance of standard deviation 20 and 30 is obtained in (Table 2) which will be same.

**Table 1: For different thresholding functions using FDR method the values of MSE and SNR are**

<table>
<thead>
<tr>
<th>Function</th>
<th>σ=10</th>
<th>MSE</th>
<th>SNR</th>
<th>σ=20</th>
<th>MSE</th>
<th>SNR</th>
<th>σ=30</th>
<th>MSE</th>
<th>SNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard function</td>
<td>44.3586</td>
<td>25.566</td>
<td>130.998</td>
<td>21.251</td>
<td>279.96</td>
<td>17.9664</td>
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<tr>
<td>Garrote function</td>
<td>51.2577</td>
<td>25.303</td>
<td>169.291</td>
<td>20.148</td>
<td>345.66</td>
<td>17.054</td>
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</tr>
<tr>
<td>Mixed function</td>
<td>46.6343</td>
<td>35.7345</td>
<td>154.682</td>
<td>20.528</td>
<td>327.678</td>
<td>17.572</td>
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</tbody>
</table>

**Table 2: Using visu shrink thresholding method the values of MSE and SNR for different thresholding functions are**

<table>
<thead>
<tr>
<th>Function</th>
<th>σ=10</th>
<th>MSE</th>
<th>SNR</th>
<th>σ=20</th>
<th>MSE</th>
<th>SNR</th>
<th>σ=30</th>
<th>MSE</th>
<th>SNR</th>
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<tbody>
<tr>
<td>Hard function</td>
<td>51.6795</td>
<td>25.275</td>
<td>159.469</td>
<td>20.463</td>
<td>331.257</td>
<td>17.226</td>
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<tr>
<td>Soft function</td>
<td>190.995</td>
<td>19.611</td>
<td>549.910</td>
<td>15.018</td>
<td>982.789</td>
<td>12.498</td>
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<tr>
<td>Garrote function</td>
<td>75.1200</td>
<td>23.665</td>
<td>242.058</td>
<td>18.588</td>
<td>495.283</td>
<td>15.484</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Mixed function</td>
<td>65.5301</td>
<td>34.257</td>
<td>217.243</td>
<td>19.058</td>
<td>447.239</td>
<td>15.925</td>
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</table>

**Graph 1:** Comparison of MSE values for different functions in FDR method.

**Graph 2:** Comparison of SNR values for different functions in global thresholding method.

**Graph 3:** Comparison of MSE values for different functions in visu shrink method.
V. CONCLUSION

In this paper to denoise the noisy biological signal a mixed thresholding function is proposed. Using ECG signals the performance of this function is evaluated. With existing hard filter, Soft function and garrote function these results are compared. From the obtained results, the performance of mixed thresholding function is better than soft and garrote functions with visu shrink method and FDR method.

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REFERENCES


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