iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** X **Month of publication:** October 2023

DOI: https://doi.org/10.22214/ijraset.2023.55612

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue X Oct 2023- Available at www.ijraset.com

Denoising of ECG and Estimation of the Baseline Using Group Sparse Regularization and Some Advanced Filtering Techniques

A. Rajani[1], Ch. Ramya Rekha[2]
[1]*Asst Professor, ECE, Department, UCEK, JNTUK, Kakinada, Andhra Pradesh, India*
[2]*M. Tech, JNTUK, Kakinada, Andhra Pradesh, India*

Abstract: In this context, the sparse features of the particular signal are taken into consideration to exhibit the technique of sparse optimization. This type of approach is derived from the traditional approach known as total variation. This traditional approach is the old one used to reduce the noise in a particular signal in order to rescue the sharp edges of the signal.

In this context, majorization and minimization are the major keys to getting the desired noise-free signal. Along with that, most advanced filters like median filters and moving average filters are considered in order to gain a noise-free signal, and the signal will be more vulnerable to identification. Using the filters discussed above, the signal can be determined in the high SNR ranges as well.
Keywords: Group sparse optimization, Total variation, Minimization-majorization, Median-filter, moving average filter

I. INTRODUCTION

In order to know the exact condition of the heart and the illness associated with it, the electrocardiogram signal is the only criteria. Due to technological advancements in the medical field, remote ECG monitoring is now possible everywhere, and this type of improvement in this particular field helps in the automatic detection of heart disorders. Signals from the ECG are polluted with unwanted disturbances and noises such as baseline wander, artefacts, and other noises from outsource. These are all together responsible for causing the disturbance in the signal. So, eliminating these polluted signals from the pure signals is very much needed in order to know the exact condition of the heart and to discover the illness incorporated with the heart. The ECG signal consists of different components, like the P-wave, QRS complex, and T-wave. The P-wave is used for starting the atrial contraction; it is the depolarization of the atria. This is followed by the contraction of the ventricles, or depolarization, and then the T-wave is used for the repolarization of the ventricles.

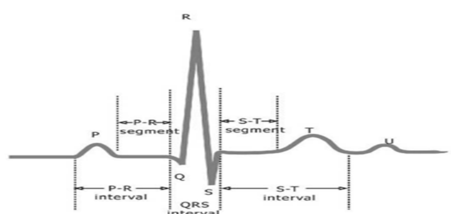
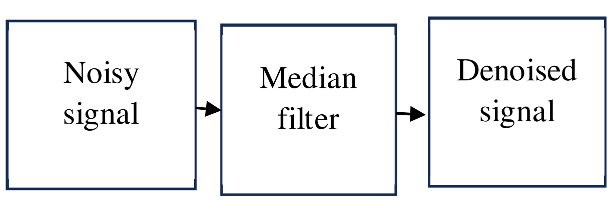


Fig.1: ECG Signal

As technology is increasing day by day, advancements in monitoring health conditions have also taken a new direction and introduced more and more advanced equipment in order to determine the ECG signal, like wearable ECG monitors, smart watches, fitness trackers, etc.In order to remove contaminated signals from the ECG signals, a number of methods are introduced, among them empirical mode decomposition and the wavelet transform.

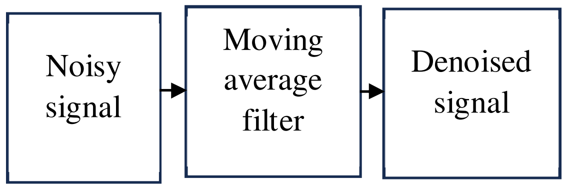
A. Median Filter



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue X Oct 2023- Available at www.ijraset.com

The median filter is one of the filtering techniques used to remove the contaminated noise in the ECG signal. To replace each element in the particular signal with the median value, which is closer to it. "Window" moves the entries at a time, and then they are sorted in descending order, and the median is calculated to obtain the denoised signal. A two-dimensional window includes all entries that come within the range of a certain bounded radius.

B. Moving Average Filter



A moving average filter, also alternatively named rolling average or running average, involves averaging various distinct subsets of a complete data set. It is also sometimes spelled moving mean or rolling mean. The subset of the number series that is initially fixed is averaged in order to produce the moving average first component. Then the subset, which is fixed initially, is altered by "shifting forward," and it includes the next value in the subset.

II. LITERATURE REVIEW

1) *M. Z. U. Rahman, R. A. Shaik and D. V. R. K. Reddy, "Efficient and Simplified Adaptive Noise Cancelers for ECG Sensor Based Remote Health Monitoring," in IEEE Sensors Journal, vol. 12, no. 3, pp. 566-573, March 2012.*

The contaminated noise in electrocardiogram data uses adaptive filters that are based on error nonlinearity, which are more complex. The suggested one will be more suitable for more advanced applications like biometry, which has high signal-to-noise ratios. These types of approaches perform least mean square (LMS) realisations by using addition and shift operations. As for the comparisons, the suggested one will perform better for all the parameters mentioned above.
Summary: Noise in ECG signals further improved.

2) *Kabir, Md. Ashfanoor and Celia Shahnaz. "Denoising of ECG signals based on noise reduction algorithms in EMD and wavelet domains." Biomed. Signal Process. Control. 7 (2012): 481-489.*

In this context, the EMD-based denoising of the ECG is introduced, which differs from the conventional approaches. In this context, they have used the EMD domain to eliminate the noise from IMFs, which helps retain the QRS complex signal. This method will not pay attention to the number of IMFs containing QRS complexes or the noise associated with them. The particular signal here is changed into the DWT domain, which helps to construct the clear one of the particular ECG signal. They have compared four MIT-BIH arrhythmia database simulations; thus, from the resulting output, the noise is further decreased, and there is high scope for getting a more accurate denoised signal.
Summary: New ECG denoising approach designed.

3) *L. Smital, M. Vítek, J. Kozumplík and I. Provazník, "Adaptive Wavelet Wiener Filtering of ECG Signals," in IEEE Transactions on Biomedical Engineering, vol. 60, no. 2, pp. 437-445, Feb. 2013.*

Signals that are extracted from the standard CSE database and noised manually are captured for testing at 500 Hz. They incorporated the signal with white Gaussian noise and altered its power spectrum. The reason for the incorporation is to match the power spectrum model of the standard EMG signal to create the illusion of fake interference. Choosing the accurate filter banks and also choosing parameters of the Wiener filter based on the signal-to-noise ratio are their main aims. They have used some filtering settings that adjust the filtering parameters with the amount of interference in the input signal in order to increase the performance of the filtering.
Summary: Reduction of broadband myopotentials (EMG) in ECG signals further improved.

4) *S. Poungponsri and X. -H. Yu, "Electrocardiogram (ECG) signal modeling and noise reduction using wavelet neural networks," 2009 IEEE International Conference on Automation and Logistics, 2009, pp. 394-398.*

In this context, in order to eliminate the noise, the wavelet neural network approach is introduced. This is the hybrid approach, which is a combination of adaptive diversity learning particle swarm optimisation (ADLPSO) and the gradient descent optimisation method.

From the resultant simulations, the approach they describe here is worth using and also efficiently eliminates the high-frequency noise.
Summary: WNN is implemented.

5) *Xiong, Peng, Hongrui Wang, Ming Liu, Feng Lin, Zengguang Hou and Xiuling Liu. "A stacked contractive denoising auto-encoder for ECG signal denoising." Physiological Measurement 37 (2016): 2214 - 2230.*

In this paper, in order to eliminate the noise from the particular signal, a new approach called contractive denoising auto encoder (CDAE) is described, which creates a deep neural network for the reduction of the noise. It increases the ECG signal expressions by using multilevel feature extraction, which is based on the Frobenius norm of the Jacobean matrix. The MIT-BIH database is used for the approach. The novel method proposed here will lead to improvements in the signal-to-noise ratio and root mean square error.
Summary: Denoising technique is further improved

III. DESCRIPTION OF THE RESEARCH

We have used majorization and minimization and other advances filters in order to obtain the noise free ECG signals
The signal x having the length of the signal as N is moulded into vector form
X=[x(0),x(1),…….,x(N-1)]^TϵR^N , where [.]^T is known as transpose.
The signal is converted into discrete domain, so the first order difference of the signal can be expressed as the

$$\mathbf{D} = \begin{bmatrix} -1 & 1 & & & \\ & -1 & 1 & & \\ & & \ddots & \ddots & \\ & & & -1 & 1 \end{bmatrix}$$

The derivative is known as Dx
The equation is introduced as y=x+w+f
Where as x=original ECG signal
f=BW signals
w=noise component
both of them combinedly form the component y

Coming to the optimization algorithm
We alter the variable as
X=Ru

$$\mathbf{R} := \begin{bmatrix} 0 & & & & \\ 1 & 0 & & & \\ 1 & 1 & 0 & & \\ \vdots & & & \ddots & \\ 1 & 1 & \cdots & 1 & 0 \\ 1 & 1 & \cdots & 1 & 1 \end{bmatrix}$$

Where Dx=DRu=u
Λ(z) represents the diagonal matrix

$$[\Lambda(\mathbf{z})] = \sum_{j=0}^{K-1} \left[\sum_{k=0}^{K-1} |z(n-j+k)|^2 \right]^{-1/2}.$$

A and B are band matrices
For Optimization algorithm of GSTV refer to[6]

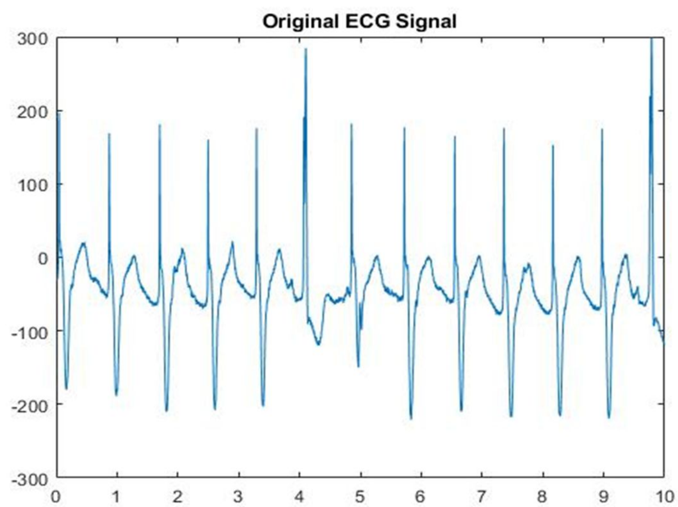
International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue X Oct 2023- Available at www.ijraset.com

A. Implementation of Advanced Filters

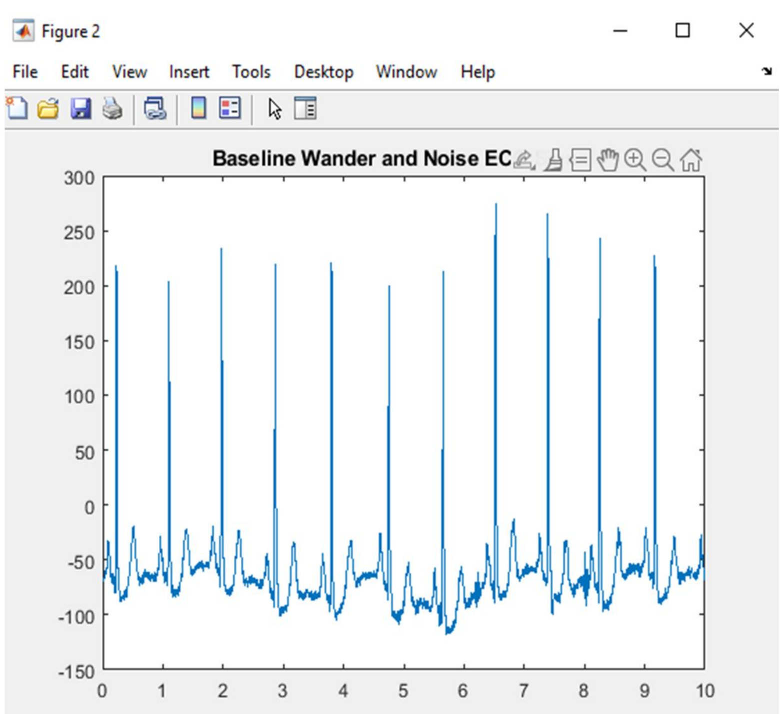
The most advanced filters, like median filters and moving average filters, are concatenated in order to get the best results at higher SNR values as well. By using these types of filters, the noise is eliminated at high SNR values.

The median filter replaces the noise component with a local median value, and in the moving average filter, the noise component is replaced with a local average value.

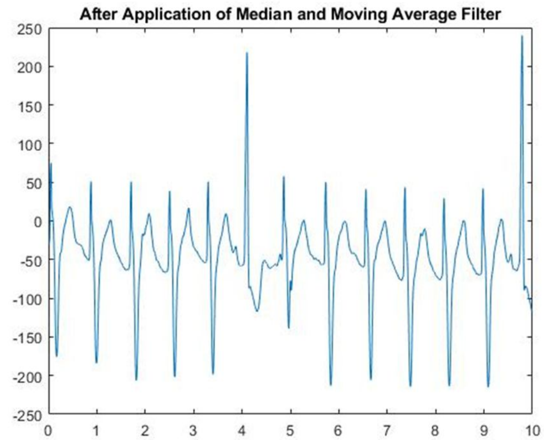
IV. RESULTS AND DISCUSSIONS



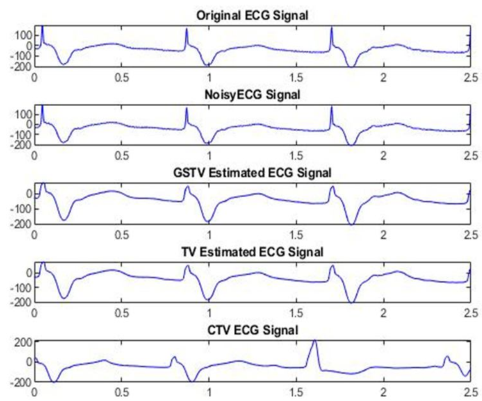
ECG signal

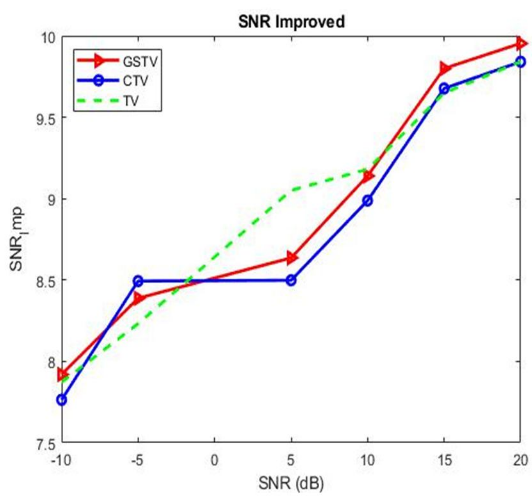


Noisy signal



After the application of the median and moving average filter





V. CONCLUSION

The unwanted noise in the signal is removed by the group sparse optimization method and also by concatenating the simplified filters like the median and the moving average filter. The proposed method is applicable at high signal-to-noise ratio (SNR) values. The minimization and majorization algorithm is the main lead in this type of approach, and the BW and other noises are successfully eliminated or reduced, and we successfully obtained a clear ECG signal. By concatenating with other filters, the denoising will be more effective, and a more accurate signal can also be obtained.

REFERENCRES

[1] M. Z. U. Rahman, R. A. Shaik and D. V. R. K. Reddy, "Efficient and Simplified Adaptive Noise Cancelers for ECG Sensor Based Remote Health Monitoring," in IEEE Sensors Journal, vol. 12, no. 3, pp. 566-573, March 2012.

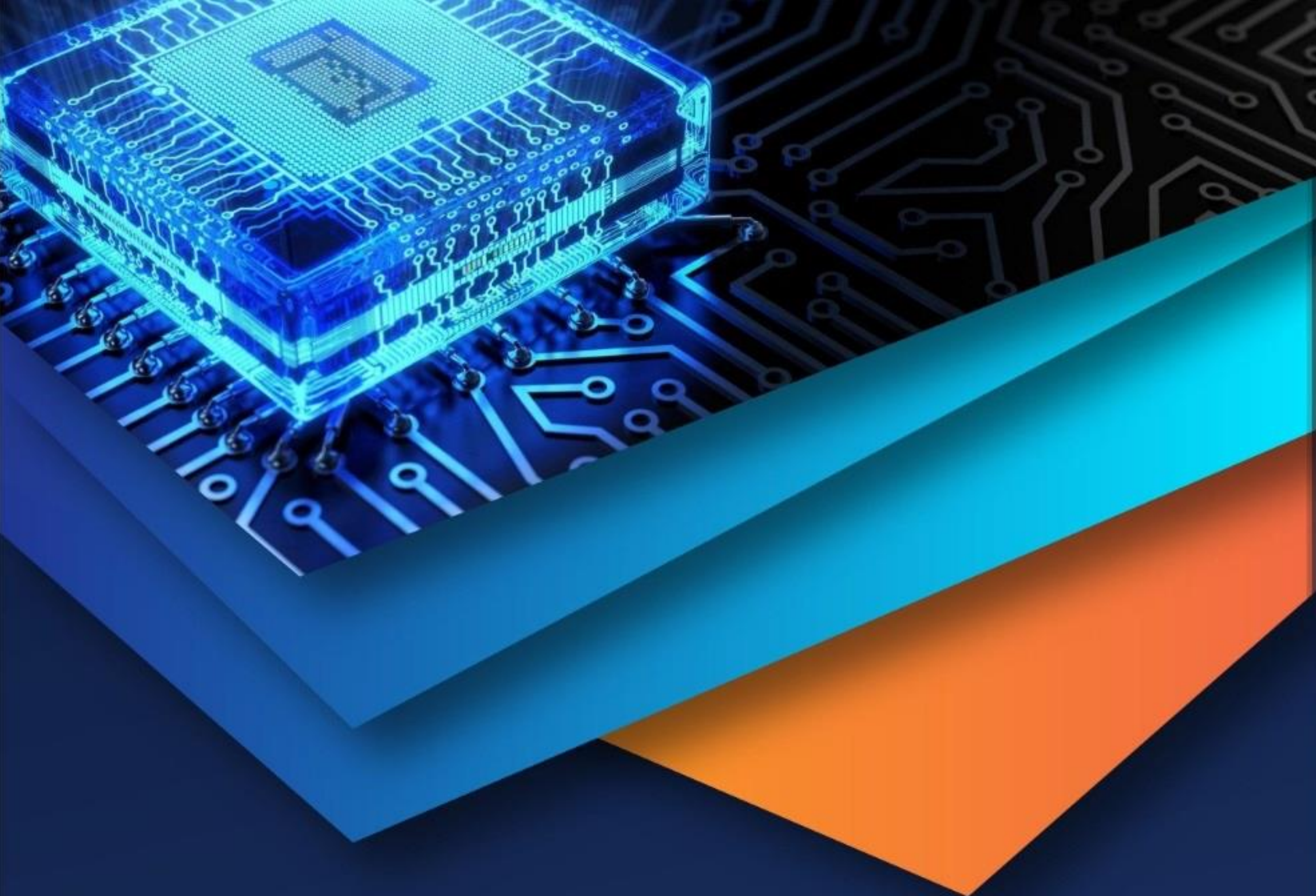
[2] Kabir, Md. Ashfanoor and Celia Shahnaz. “Denoising of ECG signals based on noise reduction algorithms in EMD and wavelet domains.” Biomed. Signal Process. Control. 7 (2012): 481-489.

[3] L. Smital, M. Vítek, J. Kozumplík and I. Provazník, "Adaptive Wavelet Wiener Filtering of ECG Signals," in IEEE Transactions on Biomedical Engineering, vol. 60, no. 2, pp. 437-445, Feb. 2013.

[4] S. Poungponsri and X. -H. Yu, "Electrocardiogram (ECG) signal modeling and noise reduction using wavelet neural networks," 2009 IEEE International Conference on Automation and Logistics, 2009, pp. 394-398

[5] Xiong, Peng, Hongrui Wang, Ming Liu, Feng Lin, Zengguang Hou and Xiuling Liu. “A stacked contractive denoising auto-encoder for ECG signal denoising.” Physiological Measurement 37 (2016): 2214 - 2230.

[6] ECG Baseline Estimation and Denoising With Group Sparse Regularization. HAO SHI , RUIXIA LIU , CHANGFANG CHEN , MINGLEI SHU , AND YINGLONG WANG



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY