

# THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

## Denoising and Extraction of Electrocardiogram Signal Using EPMD

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### Abstract:

Signal processing a major tool used for ECG analysis and interpretation in today's life. ECG signal is used to identify the different types of diseases. In ECG signal processing is used to improve the measurement accuracy and reproducibility comparatively. Separating respiration signals from ECG is one way of obtaining knowledge related to respiration especially when specialized equipments are not used to monitor the respiration continuously. There are chances of noises added to ECG signal when it is transferred via wireless medium. Some of these noises are baseline wander, power – line interference, etc. These types of noises corrupt the ECG signal resulting in a way unable to diagnose the disease. However, removing the noise can only give the exact ECG signal. Even with this we cannot identify the diseases. In order to overcome this drawback we are using Ensemble Pragmatic Mode Decomposition technique to remove these types of noises with single channel ECG based on higher order statistics. The proposed approach is altered from the existing NLMT algorithm in few aspects: the transform domain collaborative filtering and the block-based processing. The waveform of respiratory signal is reconstructed from the NLWT by processing single-channel ECG. Two techniques for the decomposition of the ECG signal into suitable bases of functions are proposed Hilbert-Huang Transform (HHT) Analysis and the Ensemble Pragmatic Mode Decomposition (EPMD) to achieve the goals. The frequency information evolving with time scales and time locations provides the performance of HHT and Ensemble Pragmatic Mode Decomposition by an analysis of Intrinsic Mode Function (IMF). This technique is used to overcome the drawbacks of wavelet approach and to extract the respiratory signal separately to easily identify the different types of diseases.

**Keywords:** EPMD, ECG Denoising, Q Peak Detection, IMF

### 1. Introduction

Electrocardiogram (ECG) is the record of the electrical potentials made by the heart. Observation of a patient's respiration signal will offer the desired info necessary to investigate a subject's wellbeing. An increase in population and the aging population demographic attributes that there's associate degree of increasing stress being placed on current tending systems.

There is need for testing to be performed outside the hospital surroundings. But due to the ambulatory nature of the recordings and the noise present the desired recording becomes unnoticeable. There's also a need for the range of sensors required to perform the desired recording to the user. Also to use it in most systems to identify the ECG signal. The extraction of a proxy for the electrocardiogram (ECG) signal has so received respectable interest from previous researchers.

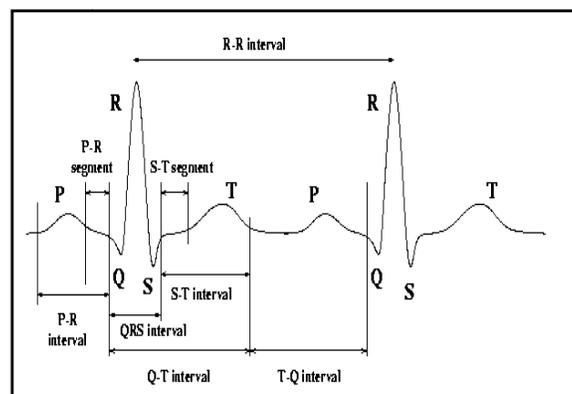


Figure 1: ECG Signal

## 2. Related Works

A revolutionary technological progress to diminish restrictions on monitoring health state provided significant breakthroughs in over a decade of years. Literature surveys show that a two-directional nonlocal (TDNL) variation model with three components using similarities is used for image denoising [19]. Image denoising was also done using higher order singular value decomposition (HOSVD) technique [17]. To enhance brain signal recordings in EEG, signal an adaptive filtering technique is used [26]. Removing noise in ECG signal can be done using various methods. Neglecting the intrinsic mode functions to reduce noise in ECG signal is done with empirical mode decomposition and discrete wavelet transforms [12]. Non linearity based adaptive filters also used for noise cancellation in ECG signal [3]. Also ECG signal is denoised with Nonlocal means (NLM) approach to improve signal to noise ratio [14]. Artificial neural network is also used in ECG signal denoising using Widrow-Hoff delta algorithm [27].

PhysioBank is a database of well characterized digital recording of physiological signal whereas PhysioNet is for open source software and the recorded biomedical signals for analyzing them [24]. Another de noising method with slight change in ECG waveform is using wavelet with soft thresholding technique which includes Donoh's statistical threshold estimator [5]. A portable device which is simple to measure ECG signal in home is developed based on the feedback from PC based ECG monitoring system where the technique [1]. Bayesian Filters which includes Extended Kalman Filter, Extended Kalman Smoother, and Unscented Kalman Filter is used to filter single channel noisy ECG signal [6]. Separating additive noise from ECG signal is done with discrete wavelet transform technique with Wiener filter [10]. Ensemble mode of decomposition was developed to measure the non stationary and nonlinear signals [4]. The EMD technique is also used to remove noise with high frequency with minimum signal distortion [11]. The proposed system briefs about the ensemble pragmatic mode decomposition technique to de noise and extract the ECG signal from noises to obtain clear understanding about the disease.

## 3. Existing Methodology

ECG signal which provides information about heart through various leads placed on the skin originates from the heart becomes noisy due to path deformities and external disturbances. Various noises like power-line interference, baseline wander, muscle noise corrupts ECG signal which provides information about heart where additive white Gaussian noise also adds at the time of wireless recording. Proposed method exploits the local and non local correlations of the ECG signal and de noises it by using non local wavelet transform. NLM technology is used to denoise the ECG image where each sample is independently estimated from the two – dimensional discrete wavelet transforms by shrinking it.

The NLWT method in overcomes the drawback of NLM by using block based processing and collaborative filtering. Block based processing includes sample blocks instead of individual samples which produces multiple estimates for the sample. Final estimate is obtained by averaging the estimates which adds an extra smoothing layer where it resolves the problem of assigning inappropriate weights. The three important steps as SDM extraction, the transform coefficients shrinkage and the aggregation. SDM extraction with reference block will search similar blocks. Shrinking of 2D DWT co efficient to denoised the signal is effective and simple way to exploit inter column and inter row correlations. Aggregation helps in obtaining denoised signal by returning denoised SDMs.

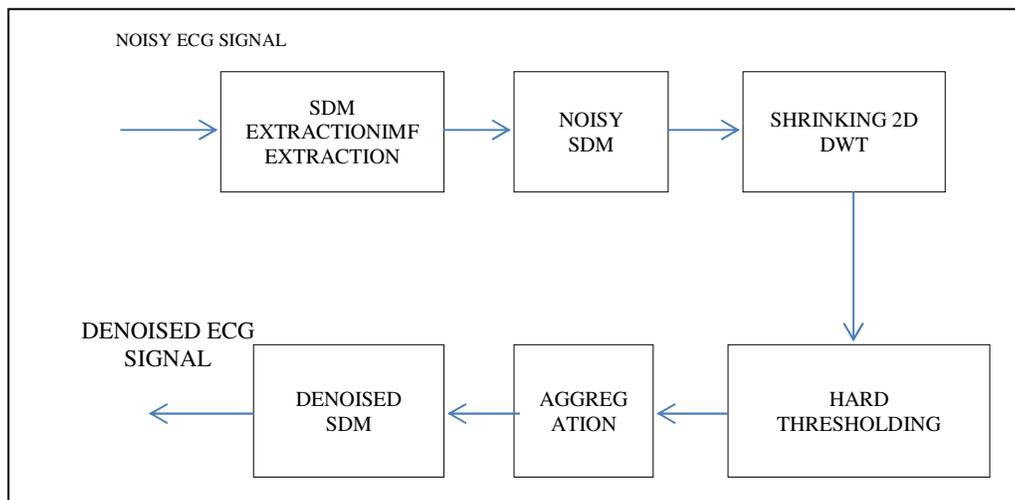


Figure 2: Block Diagram of Existing System

## 4. Proposed Methodology

Separating noiseless ECG signal from Noisy ECG signal will help in obtaining the knowledge about ECG signals and will be useful in the situation where ECG is not monitored routinely by special equipment. There are many methods that provide reasonable results for separating noise from ECG signal but still there are some drawbacks like requiring multichannel ECG signal, less against noise – being robust, etc. In this method we overcome the drawback by using single – channel ECG signal to obtain the knowledge on higher order statistics which is notable feature from conventional methods. To underline the limitations of wavelet approach and to emphasize the different performance EPMD and HHT techniques are used. Hence to monitor the ECG signal indirectly EPMD algorithm is significant.

#### 4.1. Modules

- WAVELET TRANSFORMS
- ENSEMBLE PRAGMATIC MODE DECOMPOSITION
- ECG SIGNAL EXTRACTION
- QRS DENOSING

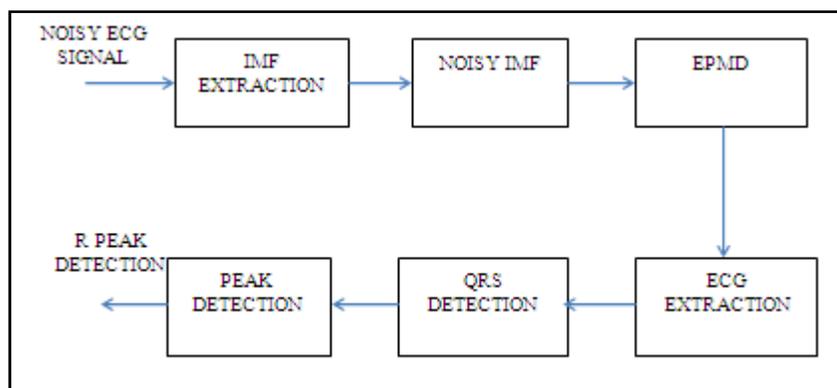


Figure 3: Block Diagram of Proposed System

#### 4.2. Wavelet Transforms

The signal is decomposed with wavelet transform based on the set of bases function. There are two parameters that basis vector function depends on: the dilation coefficient ( $a$ ) and the translation step ( $b$ ). The original signal is recovered by compressing or stretching and translating the wavelet function  $\psi(t)$ .

#### 4.3. Ensemble Pragmatic Mode Decomposition

The time series is decomposed into individual components in EPMD technique as in wavelet technique where structural and local temporal characteristics are exploited. EPMD is achieved from the original ECG signal through sum of approximations. Here we have examined univariate time series for EPMD technique. In EPMD technique original ECG signal is approximated as sum of linear components. EPMD decomposes the signal into intrinsic mode function and residues. EPMD is started by estimating the sum of high frequency and low frequency components locally. The high frequency components are intrinsic mode functions and low frequency components are residues. IMF and residues are extracted continuously. The IMF and residues are added at the end of decomposition. The below flowchart depicts the process flow of EPMD.

EPMD algorithm is applied to extract ECG signal from the experimental signal after the pre-processing stage. EPMD shows better performance and the recorded RS signal is compared with the results obtained. Three different conditions for recording (supine, standing, light activity) were analyzed. The SNR value calculated from the denoised signal is better than other conventional methods. The signal extraction provides more information on the diseases.

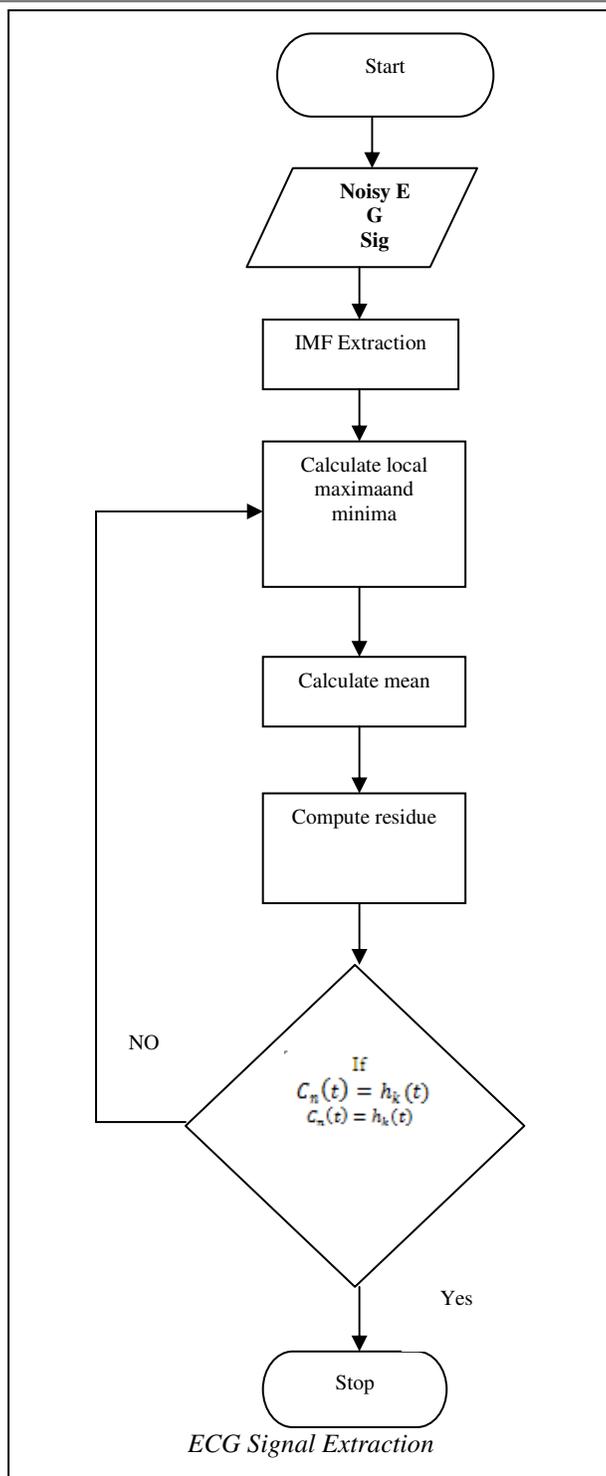


Figure 4

#### 4.4. QRS Denosing

Electrocardiogram (ECG) signal denotes the heart's contractile activity which is electrical manifestation of heart. During recording the ECG signal is contaminated artifacts and noises which can be within band of interest (0.5 – 100 Hz), where power-line interface (PLI), baseline wander effects and EMG are the most common artifacts encountered. The interferences like PLI are eliminated and Baseline-wander is corrected from ECG signal using EPMD technique. The intrinsic mode function has local maxima and local minima from which the noise is removed. Smoothing is done to get smooth signal.

#### 5. Implementation Results

The signal to noise ratio is calculated using the below equation. Here we have used two samples with different noise ratios and calculated the SNR. The table depicted below shows the difference in signal to noise ratio.

$$SNR_{imp} = 10 \log \frac{\sum_{i=1}^N (v[i] - u[i])^2}{\sum_{i=1}^N (\hat{u}[i] - u[i])^2}$$

5.1. Sample 1

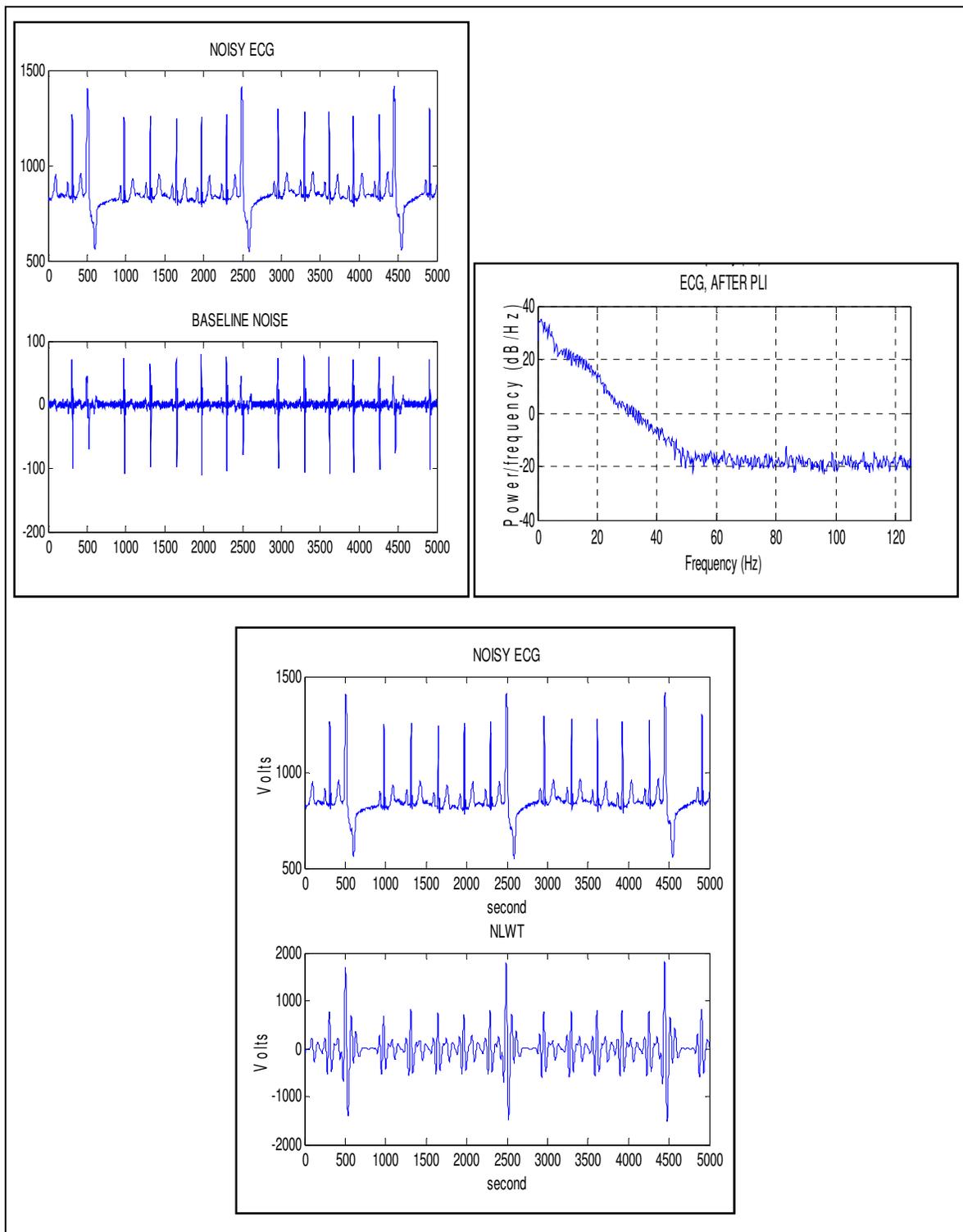


Figure 5

5.2. Sample 2

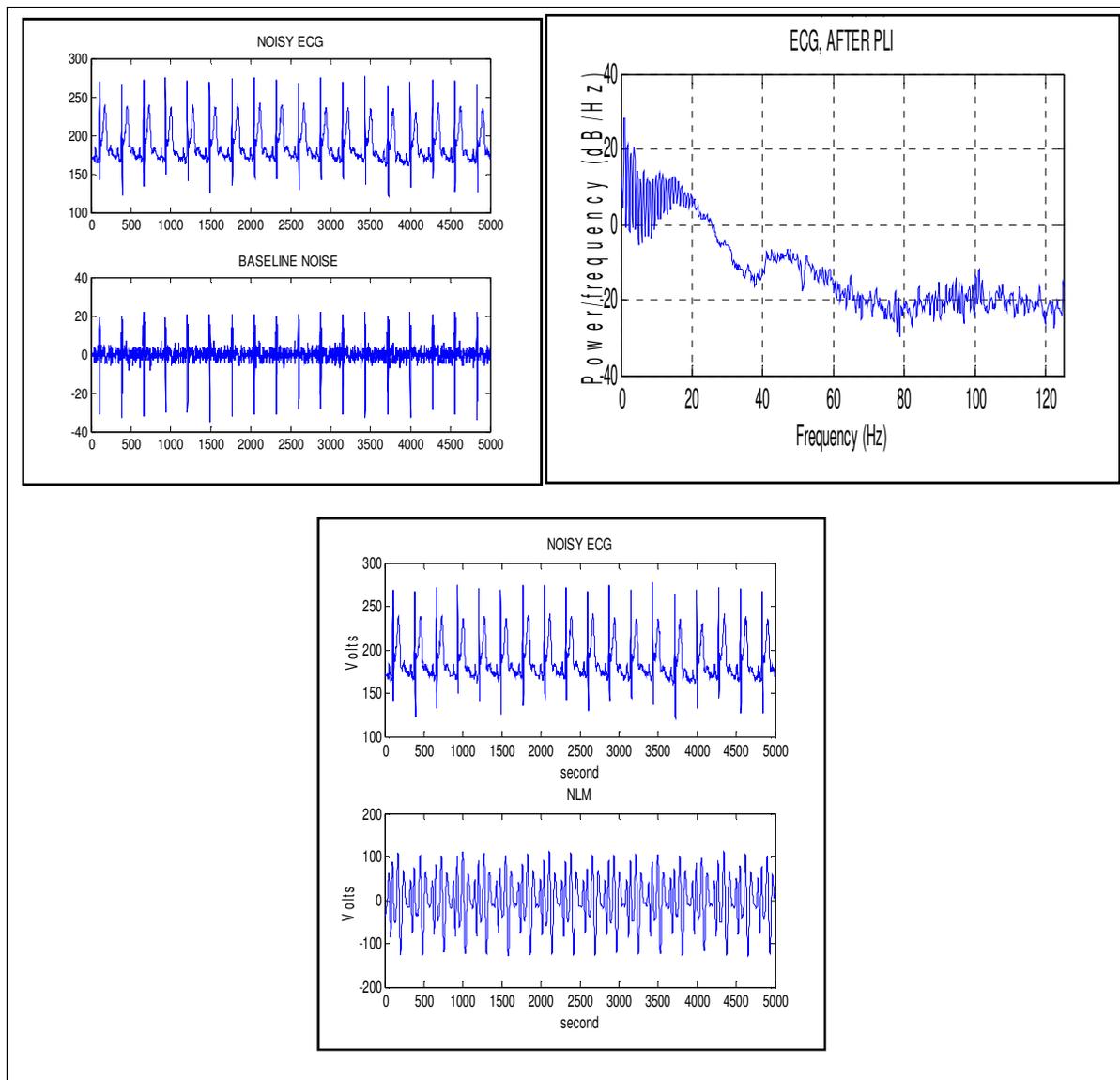


Figure 6

Signal	Existing SNR	Proposed SNR
1 <sup>ST</sup> SAMPLE	10.8860	12.125
2 <sup>ND</sup> SAMPLE	7.785	8.3895

Table 1

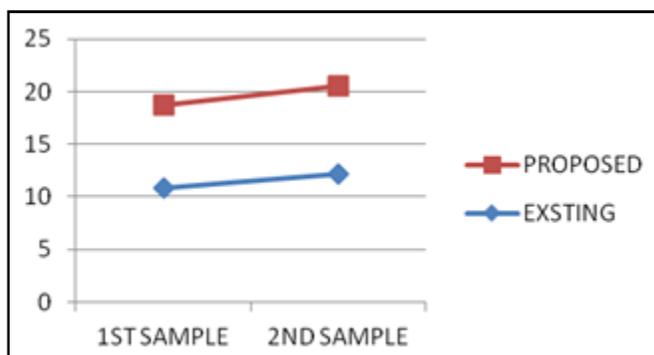


Figure 7

## 6. Conclusion

A comparison for extracting ECG signal between two methods from single-channel ECG has been carried out in this paper. It is shown that how EPMD algorithm leads to extract the ECG signal using both techniques to recover the shape of ECG signal and in turn leading to better results. The limitation of NLWT has been overcome here because the basis is generated by a data driven heuristic procedure from the analyzed signal. Also the signal to noise ratio is compared with NLWT and EPMD techniques and the same is tabulated.

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