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Study on Different Techniques for Denoising of ECG Signal

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Abstract: In medical field for diagnosis of heart diseases electrocardiogram (ECG) is used and plays very important role. For better diagnosis a good quality ECG signal is required. Sometimes the problems occur is that noises corrupt the previously recorded ECG signals, significantly they are of two types:-electromyogram induced high-frequency noise, electrodes experience mechanical force, baseline wander this may be due to breathing process or the motion of the patients or the instruments. So that there will be wrong diagnosis. This paper introducing Emperical Mode Decomposition method for denoising of ECG, also introducing other methods for denoising included ecg analysis based on wavelet transform and modulus maxima, time-frequency dependent threshold, artificial neural networks and mathematical algorithm using window analysis.

Keywords: ECG, Window analysis, ECG Denoising, baseline wander, Artificial Neural Networks.

1. INTRODUCTION

The electrocardiogram (ECG) is the graphical representation of the cardiac activity and it is used to diagnose the heart diseases.

The electrocardiogram (ECG) signals show the reflections of heart conditions and hence any abnormalities can be found out by analyzing the ECG signals.It becomes very tough even for a trained physician to make a proper diagnosis. In the computer technologies researchers are getting help by its applications so that can assist in accurate analysis of the ECG signal. Main reason of wrong interpretation are Noises in the ECG signals. So that for further processing and to improve the quality of the signal preprocessing is significant. There are two important artifacts that get intermixed with the ECG are high frequency noise that includes electromyogram noise (because of muscle's activity), motion artifacts (because of electrode motion) [4], channel noise (White Gaussian Noise introduced during Transmission through channels), and power line interferences and the low frequency noise i.e., baseline wandering because of breathing or coughing [1].In the literature for ECG denoising Number of techniques have been reported. That uses morphological filter to remove the MA Noise [4], adaptive algorithm (RLS) [5], wiener filtering [6], wavelet transform (WT) [7]-[11], advanced averaging technique [12], [13], independent component analysis [14] and BWT (bionic wavelet transform) showing better result over WT [15].

To obtain information of the signal or noise before processing is practically impossible. Hence, for the denoising of ECG here EMD technique has been used as it is an adaptive mechanism to decompose any signal that doesn't need the prior information and this mechanism is introduced by Huang et al. [16].

EMD has also been used as a very powerful technique to denoise the ECG Signals [20]-[23].

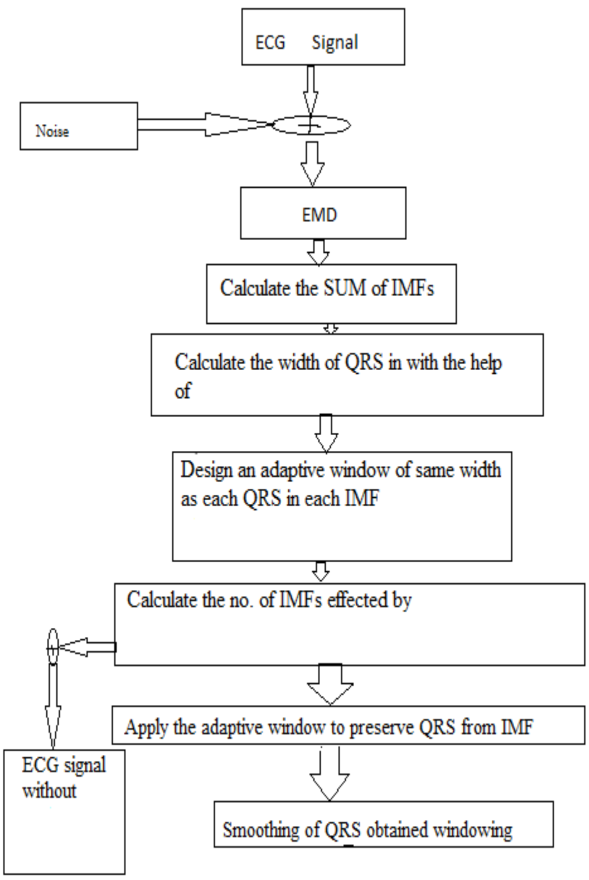

Fig.1 Block diagram of modified EMD based algorithm for denoising of the ECG signal

2. EMPERICAL MODE DECOMPOSITION

The process is useful for analyzing natural signals, which are most often non-linear and non-stationary. Empirical Mode Decomposition (EMD) was developed by Huang et al.The functions, known as Intrinsic Mode Functions (IMFs), are therefore sufficient to describe the signal, even though they are not necessarily orthogonal, that must follow two conditions: (i) the no of local extrema and the zero crossing must be equal or differ by at most one, (ii) at any point of the time, the mean value of the upper envelope (local maxima) and the lower envelope (local minima) must be zero.) the fastest oscillation, subtract it to the initial signal and iterate on the residual:
1) identify local maxima and minima in the signal
2) deduce an upper and a lower envelope by interpolation(cubic splines)

After finding the extrema, an upper envelope is formed by connecting all the local maxima by a cubic spline line. Similarly the lower envelope is formed by all the local minima. Now their mean is calculated and the difference between the signal data and this mean is found and stated as the first component. To preserve the QRS complex, we need a delineation of the QRS complex. Experiments show that sum of 1st 3 IMFs (im=imf1+imf2+imf3) preserves the morphology of the QRS complex [20].The basis functions are in this case derived adaptively directly from input data. An IMF resulting from the EMD shall satisfy only the following requirements:
1) The number of IMF extrema (the sum of the maxima and minima) and the number of zero-crossings must either be equal or differ at most by one;
2) At any point of an IMF the mean value of the envelope defined by the local maxima and the envelope defined by the local minima shall be zero.

It has been examined by performing various experiments for both synthetic as well as real noise cases and for the noisy ECG signal (record 103) having white Gaussian noise with 10dB SNR, it has been noticed that the width of the QRS complex will be lost if the local minima is considered whereas the choice of taking local absolute minima solves this problem of misinterpretation for the actual width to be preserved. Again as we are dealing with the discrete time signal (ECG signal for computer added work and processing), thus many times it is not possible to have the sample value at exact zero crossing point[1].

3. OUTCOME OF EMPERICAL MODE DECOMPOSITION MEHTOD

The technique explained in this work intended that on applying empirical mode decomposition to the noisy ECG signal, IMFs include both, the content of the signal as well as noise components, thus only preservation of the useful content of the signal i.e the actual ECG signal is being considered as the main aim. The proposed method is upgradation towards the existing EMD based denoising approaches. This approach of denoising includes the adaptive window technique followed by the smoothing of the preserved QRS complex within the specified QRS duration so that the reconstructed signal achieved is very much similar to the actual ECG signal. The subjective as well as computable results achieved for various different experiments show that the suggested algorithm is very much effectual and promising one for the denoising of the ECG signal without changing the actual feature of the signal. Here one more approach has been made known to the QRS complex preserved after doing window function. It removes the additional peaks, due to which the actual feature of the QRS complex was deformed caused due to noises. The combination of the modified EMD approach and smoothing makes the algorithm very much realistic and applicable and can be applied in long term examination of the ECG signal in practical stress test as well as in Holter monitoring that may get affected by the prominent noises.

APPLICATION OF WINDOW ANALYSIS IN MATHEMATICAL ALGORITHM FOR DENOISING

Dominant scale of QRS complexes is one of the two informations on which the mathematical algorithm is based and another is their domain. This has been done by using a varying-length window which moves over the signal length. Noise and base-line wandering signal both are assess for manually corrupted ECG signals and are verified for true recorded ECG signals.

OUTCOME OF APPLICATION OF WINDOW ANALYSIS IN MATHEMATICAL ALGORITHM FOR DENOISING

There are some limitations in this denoising algorithm, these limitations will come into view if:
• Pre-stage detection of R-waves fails.
• The smoothness and morphology preservation of denoise ECG signals strongly depends upon parameters α and β.
• The morphology of QRS complex is a protracted by little dominant scale.

A mathematical algorithm for denoising ECG signal is proposed here.
The benefits of this algorithm are:
• Mathematically less complex algorithm
• Safely store QRS complex characteristic points, specially Q and S waves.
• For ECG denoising Low response time

4. NEURAL NETWORK APPROACH TO REMOVE NOISE IN ECG SIGNAL

Using three unseen layers ECG denoising method based on a feed forward neural network. This technique is specially use for high corrupted and damaged signals. his initiation uses the available ECG channels to remake the corrupted and damaged channel. We examine the method, on every records from Physionet MIT- BIH Arrhythmia Database, adding electrode motion artifact noise and it increase the performance of available ECG analysis programs on corrupted ECG signals.

5. NEURAL NETWORK ARCHITECTURE AND TRAINING

In this system three hidden layers has been used with Neural network in which 1000 units on each layer.
The sequence of time segment is used to train the neural network, each one starting five samples after the beginning of the previous one. Fiducial points is not used to create input data to the neural network.
To learn the neural network weightsGeoffrey Hinton's method [24, 26, 27] is applied : following initialization using a stack of Restricted Boltzmann Machines, back propagation algorithm is used to fine tune the weights. firstly we applied a moving average filter to reduce the baseline wanderwith the window size equal to the sampling rate. Then after we subtract the result from the signal. The more effective is Median filter to remove baseline wonder in place of the moving average filter. At last, we scaled the output signal to have unit variance and multiplied the input signals by the same scale factor.for reducing training and reconstruction time, implemented this method by GNU Octave language we ran the code on a Graphics Processing Unit. The common way to do this is to add noise to an existing signal and measure the Root Mean Square Error (RMSE) of the processed signal relative to the original signal.
Some drawbcks are there: 1) It is tough to ignore noise in the original signal for large data base of ECG and we cannot trst on the denoising method for not reconstructing the noise in the original signal.
2) RMSE does not always shows the problems facing in analysing a noisy ECGFor instance, a constant baseline shift in the reconstructed signal is not very disorder, but might correspond to a high RMSE value.
This review paper showsRMSE in the reconstructed signal when artificially adding noise in the ECG.
Comparison of results of applying these programs with and without denoising the corrupted ECG.

6. RESULT OF NEURAL NETWORK ARCHITECTURE AND TRAINING

In previously available record we have added noise and performed some practicals on all the records from the MIT-BIH Arrhythmia Database. when we applied our denoising method to the ECG Our experiments shows much better performances.QRS detectors show a slight reduction in sensitivity although there is an improvement in the positive predic-tivity.
For low noise, above 12db SNR, in our method, The experiments with records mgh124 and sele0106, without adding noise in the test, confirm the advantages of using our method on a real ECG, a Holter record, for example. The experiment with record sele0106 also shows that the result of reconstructing a noisy channel can be extraordinary good when clean channels are available.

7. RESULT AND ANALYSIS BASED ON WAVELET TRANSFORM AND MODULUS MAXIMA

A technique We have developed of P,Q, R, S and T Peaks detection using Wavelet Transform (WT) and Modulus maxima. One of the common problems in electrocardiogram (ECG) signal processing is The baseline wander removal suppression. To make simpler the detection of the peaks P and T we have removed the baseline wander. These peaks detected by QRS. The proposed method is based on the application of the discritized continuous wavelet transform (Mycwt) used for the Bionic wavelet transform, to the ECG signal. Finally the Modulus maxima are used in the undecimated wavelet transform (UDWT) domain in order to detect the others peaks (P, T) in order to detect R-peaks in the first stage and in the second stage, the Q and S peaks are detected using the R-peaks localization. In order to detect R-peaks in the first stage and in the second stage, the Q and S peaks are detected using the R-peaks localization. In this detection we using a varying-length window that is moving along the whole signal. For evaluating the initiated method, we have compared it to others techniques based on wavelets. In this evaluation, we have used many ECG signals taken from MIT-BIH database. The obtained results show that the proposed method end-performs a number of conventional techniques used for our evaluation.

8. CONCLUSION

Wavelet transform and modulus maxima are fast for ECG analysis. Whereas in Emperical mode Mathematical algorithm using window analysis technique is based on theoretical facts, which is different from practical facts. For ECG denoising In neural network approach the quality of ECG signal depends upon the channel, which can not be predetermine. Decomposition technique the filters are flexible with data length and aim is extracting the original ECG signal without or minimum noise, therefore it is the best among the various denoising techniques.

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