A Wavelet Approach To Reduce Noise In ECG By Using Genetic Algorithm

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ABSTRACT:

The Electrocardiogram (ECG) is a vital bio-medical signal recording the heart's electrical activity. Analysis of ECG results in other applications such as stress recognition, bio metric recognition etc. Any changes in filtering quality directly effects the medical diagnosis

.Using wavelet along with genetic algorithm will be devising to automatically search the QTCF parameters for different noisy signals .The following paper discusses about the smooth transient suppression by genetic algorithm and its adaptability for noise reduction in various signals.

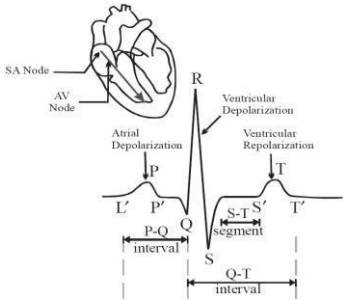
Keywords: Genetic algorithm, ECG, QCTF, TRANSCIENT SUPPRESSION, Wavelet filterin

I. INTRODUCTION

The ECG signal is a very important bio-medical signal that allows to monitor contractile activity of the heart. It is an important physiological signal for diagnosing the patients suffering from various cardiac related diseases. Basically ,ECG is a non-stationary signal i.e., random with small amplitude, usually of range 10μV~5mVand has very low frequency from 0.05Hz to

100Hz.

An ECG measure changes in electrical potential over time. The electrical potentials are caused by a group of specialized cells in the heart which control the heartbeat. These cells produce electrical impulses which spread across the heart causing it to contract. The heart's main pacemaker is placed at the Sinoatrial node (SA node) for ECG extraction.



shown in fig.1

P complex – caused by firing of SA node and the contraction of the atria (atrial depolarization)

QRS complex – caused by the firing of VA node and the contraction of the ventricles (ventricular depolarization)

T complex - caused by recovery of the ventricles after contraction (ventricular re polarization)

While these three main complexes may be sufficient for diagnosis purposes, more signal features are required to be able to differentiate individuals from large populations.

Therefore, the ECG signal is often affected by various types of noise such as power line interference, electrode contact noise, motion artifacts, EMG noise, and instrumentation noise.

The noise filtering is a crucial task before extracting medical features of ECG signals. Wavelet transform has been proven as a powerful tool for ECG signal analysis. It not only localizes the information of signals in the time-frequency plane, but is capable of trading one type of resolution for the other, which makes it especially suitable for the analysis of non-stationary signals such as ECG signals .Traditionally, various kinds of spatial filters have long been used for removing the noise in the signals. Using these filters usually reduce the noise by smoothing the data. But, in the process some of the original data is lost. In the recent years, several new techniques have been developed that improve on spatial filters by removing the noise more effectively while preserving the edges in the data having adaptability.

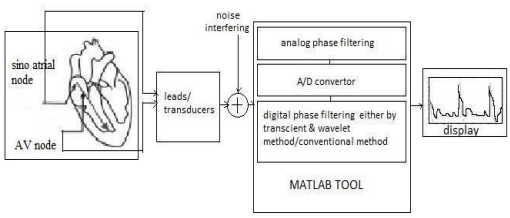


Figure1: ECG pulse complexes

The three main complexes of the heart beat are as

A Wavelet transform can be considered as a best technique for processing the non-stationary signals such as ECG, EEG, PCG etc as shown in fig.2. While there are different ways to apply wavelet transforms either by wavelet modulus maxima or wavelet thresholding. In modulus maxima, results are unstable even though process of calculation is great and hence wavelet thresholding's is used where signal with noise is analyzed in different coefficients which are divided to frequency bands. While Wavelet thresholding contains hard and soft thresholding, these have their own advantages and disadvantages i.e In soft thresholding, they are shrinkage's of large coefficients tending to bigger bias and hard thresholding can be unstable and tends a big variance, as it is sensitive to small changes in data.

However due to fixed transition curve threshold considered in the methods for processing shrinkage functions are not adaptable to different signals .To avoid the above situations optimal algorithms such as

Least Mean Square(LMS) Algorithm Genetic Algorithm

Modified Memetic Algorithm

In LMS Algorithm, the tracking of changes in input of filter depends on step size, its disadvantage is to stuck at local minimal points. In MMA, global search techniques are combined within local search and each generation have the ability to adapt from neighbors to improve them. While Genetic algorithm is mostly preferable and is considered as optimal solution .Operators such as evaluation, selection, crossover and mutation are used in the algorithm pseudo code.

II. PROPOSED METHOD

In this paper there is a new approach to remove the noise in signal by decomposition and by means of transient suppression through certain levels in signal by identifying the components by genetic algorithm unlike additional parameter such as fitness function.

An input ECG is considered from MIT-BIH database. Assume some noise be added to the input while taking it through lead from nodes ex: sino atrial node. Noise maybe EEG, PCG or any power line interference effecting on the

Figure2: Block diagram of ECG noise discussion

the genetic optimized wavelet thresholding for signal filtering can be described as follows:

1. Initialization

a) Decompose the noisy signal in sub-bands

b) Input parameters: iteration number Gm, code length L and population size N.

c) Randomly generate M individuals to form the initial population P in the parameter solution space.

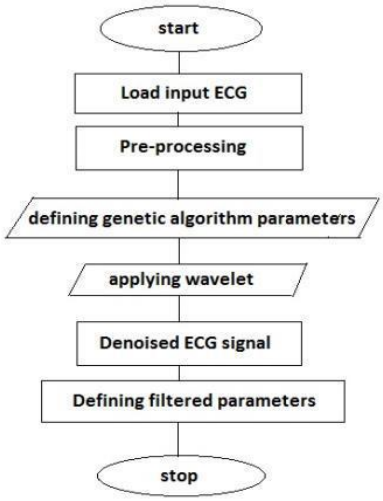


Figure3: Flow chart

2. Evaluation of individuals

a) Calculate the parameters of QCTF determined by each individual.

b) Filter the noise from the original signal through the QCTF decided by each individual and reconstruct the signal

3. Generation of new population by genetic operations

4. Termination discrimination

i.e. s_n be the ECG taken from patient as shown in Figure(5a) and d_n be the noise added as shown in the

Figure(5b) and the distorted signal formed be x_n

i.e., x_n= s_n + d_n --Figure(5c)

Now, set the initializing parameters for the pre-processing of the signal as shown in fig.3 i.e. sampling frequency (fs), band width (BW) requirement, samples to be taken under pulse for analysis (M). Now, Calculating x_n(1) , x_n(2) ,.....x(M-1),x(M).But, for a better analysis. Choose arbitrary initial conditions (x [-1], x [-2], y[-1], y[-2]). x_1 = 0 = x[-1] ; x_2 = 0 = x[-2];

Then resultant initial transform arbitrary coefficients become y_1 = 0 = y[-1;] y_2 = 0 = y[-2].

Number of initial samples to consider for the transient% suppression technique

y_n(1) = 0.5 * ((1 + a2)* x_n(1) - 2*a1*x_1+ (1 + a2)*x_2) + (a1*y_1) - (a2*(y_2));

y_n (2) = 0.5 * ((1 + a2)* x_n(2) - 2*a1*x_n(1) + (1 + a2)*x_1) + (a1*y_n(1)) - (a2*y_1);

Calculating for all output samples from 3 to N n = 3: N

y_n (n) = 0.5 * ((1 + a2)* x_n (1,n) - 2*a1*x_n(n-1) + (1 + a2)*x_n(n-2)) + (a1*y_n(n-1)) - (a2*y_n(n-2));

Now, the calculated parameters are to be maintained in matrix form tool analysis i.e Constructing input data vector X and projection matrix P.

X = x_n(1:M)'

A (1:M,1) = cos((0:M-1).*w0) A (1:M,2) = sin((0:M-1).*w0) P = A*inv ((A'*A))*A';

Now, Calculating the M samples as (I-P) X

I = eye (M)

y_n = ((I - P) * X)'

the parameters of QCTF determined by each individual are obtained and then Filter the noise from the original signal through the QCTF decided by each individual and reconstruct the signal to be done.From n = M+1 to N, Calculate the output

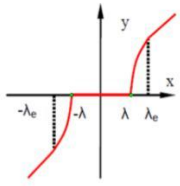


Figure 4: QCTF forming due to parameters

y_n(n) = 0.5 * ((1 + a2)* x_n(1,n) - 2*a1*x_n(n-1) + (1 + a2)*x_n(n-2)) + (a1*y_n(n-1)) - (a2*y_n(n-2))

The following output parameters are now processed through wavelet with a threshold level to reduce the noise in the ECG .Assume coiflet be wavelet used with a level = 5 for denoising the distorted ECG. If wavelet thresholding to be consider, to obtain a optimal response soft thresholding is preferable. Assume

ThrSettings = 5.0073

Now Comparing the filtering quality between normal conventional method and transient suppression method by means of RMSE (Root mean square error) and SNR (Signal to Noise ratio).

Root Mean Square Error: It is the standard deviation of the residuals (prediction errors). Residuals are a measure of how far from the regression line data points are; RMSE is a measure of how spread out these residuals are. In other words, it tells you how concentrated the data is around the line of best fit and it is also known as *Quadratic Mean*.

RMS value of a signal should be maintained low so as to obtain a efficient signal.

$$RMSE = \sqrt{y\_n^2 - x\_n^2}$$

***Signal to Noise Ratio*:** The Ratio of input noise to output noise gives the SNR of the signal. Usually, SNR of a signal should be high so that original data of input signal is more compared to noise interfered in it.

$$SNR = \frac{p*signal}{p*noise}$$

Table.1 Filtering parameters

Type of Method used	**RMSE**	**SNR**
Conventional filtering method(notch)	35.5088	0.9703
Transient suppression method	34.0822	1.0000

The graphs simulated in the analysis are as

follows

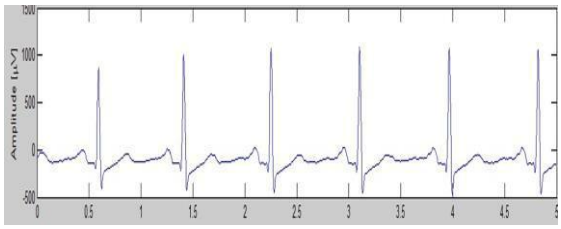


Figure 5a: Input ECG

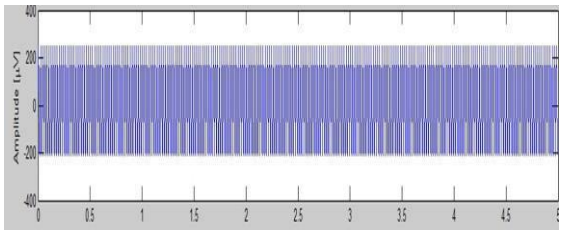


Figure 5b: Noise added to ECG

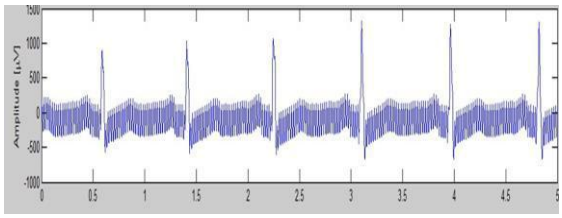


Figure 5c: Distorted ECG

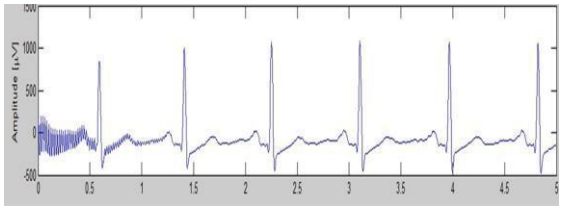


Figure 5d: ECG filtered by Conventional method

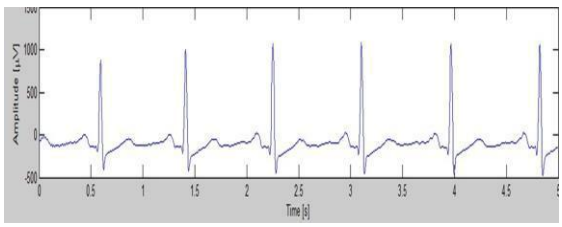


Figure 5e: ECG filtered by transient suppression

V. CONCLUSION

The ECG signal diagnosis plays a major role in the biomedical field for analysing of cardiovascular diseases. Therefore filtering it also plays a prominent role and as the wavelet thresholding filtering has become one of popular methods for ECG signal filtering providing the good performance in time-frequency domain. But, hard thresholding causes Gibbs phenomenon while using soft thresholding makes a constant bias to the filtered coefficients. Hence, Genetic Algorithm utilization to obtain a quadratic curve thresholding function (QCTF) is utilized to mimic the best connection between the cut off threshold point and the real coefficient curve by transient suppression is discussed in the paper. As discussed above following the procedure not only overcome disadvantages of hard thresholding and soft thresholding, but strengthen the adaptability of wavelet thresholding to various signals. The denoised ECG signals by the transient suppression through genetic algorithm are more suitable for feature extraction of medical diagnosis than those by hard thresholding and soft thresholding of wavelet as they provide better adaptability and filtering performance they will have good application prospect for other signal analysis in the future purpose

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