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Research Article

Enhancement of ECG signal by DFT using Fast Fourier Transform (FFT) Algorithm

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Abstract

A primarily diagnostic tool for cardiovascular diseases ECG, a non invasive technique generally used during acquisition and transportation. Noises like channel noise, baseline wander noise, muscle artefacts, electrode motion, often embedded with ECG signal. In this paper a methology to overcome from channel noise embedded during the transportation of ECG signal, proposed in this methodology DFT of noisy ECG signal calculated using fast fourier transform (FFT) algorithm. The experimental result demonstrate the proposed method is superior to other with higher SNR and lower RMSE factor, performance comparison at 1.25 dB is demonstrated.

Keyword: *ECG, Channel noise, Gaussian function, FFT, Wavelet transform, S-Transform.*

1. Introduction

ECG Electrocardiography is a technique which maps electrical activity of heart at the graph paper it is a non-invasive technique. In this technique several electrode placed on the skin at specific point on the body. Since the electrical activity is directly correlated to heart functioning. It can be used to inspect the regularities and rate of heart rhythms. Therefore any change in heart rhythm caused by cardiac rhythms will reflect in the person ECG also during acquisition and transmission, ECG signal are generally affected by different noises such as Gaussian noise in channel, baseline wander, muscle artefacts and electrode motion.

Muscle artefacts caused by the muscle activity and electrode motion due to the shifting of electrode location. Baseline wander is the variation in the isoelectric line of ECG which can occur during respiration. Poor channel condition is also caused noise in the ECG signal during its transmission. This noise corrupts the signal and makes the analysis time. Hence noisy ECG signal must be enhanced by removing the noise component at the time of processing.

There are various techniques in the literature for enhancements of ECG signal same of wavelet denoising, S-transform and many more. Most of these techniques concentrated only on kind of noise type. In this paper a new method for ECG signal enhancement using fast fourier transform effecting to overcome the channel noise limitation. During acquition of ECG signal the channel noise added while signal is transported. This paper proposed a generalised approach for ECG signal enhancement techniques and does not require any prior information like R peak position or references position. FFT is closely related to the DFT and SFT (Short Fourier Transformation)the proposed algorithm is evaluated for white Gaussian noise by means of SNR (Signal Noise Ratio) and RMSE (Route Means Square) error and experimental result shown that the proposed method result better performance compare to commonly use wavelet transform and S-transform. The performance of different ECG enhancement technique at 1.25dB input SNR and RMSE also compared.

2. FFT (Fast Fourier Transform)

The fast fourier transform (FFT) is an algorithm that efficiently compute the discrete fourier transform (DFT). The DFT of a sequence {x (n)} of length N is given by a complex-valued sequence {X (k)}

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{-j2\pi nk/N}, \quad 0 \le k \le N-1 \qquad (1)$$

Let W_n be the complex – valued phase factor, which is an N^{th} root of unity expressed by

$$W_n = e^{-j2\pi/N} \qquad (2)$$

Hence X (k) becomes

$$X(k) = \sum_{n=0}^{N-1} x(n) W_N^{nk}, \quad 0 \le k \le N-1 \qquad (3)$$

Similarly IDFT becomes

$$x(n) = \frac{1}{N}\sum_{k=0}^{N-1} X(k) W_N^{-nk}, \quad 0 \le n \le N-1 \qquad (4)$$

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An efficient algorithm for DFT computation is the fast Fourier transform algorithm because exploit the two property symmetry and periodicity property.

Symmetry property $W_N^{k+N/2} = -W_N^k$ (5)

Periodicity $W_N^{k+N} = W_N^k$ (6)

It is evident from the equ.(1), (2) and (3) for each value of k , the direct computation of X(k) involves N complex multiplication (4N real multiplication) and N-1 complex additions (4N-2 real additions). Therefore to compute all N values of DFT, N^2 complex multiplications and N (N-1) complex additions are required.

3. Methodology

The enhancement of ECG signal throw FFT it can we achieved with the help of proposed methodology show the fig. (1).

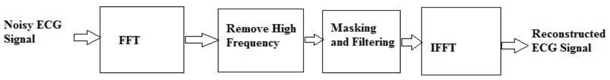

Fig.1 Block diagram of ECG enhancement technique

Step 1 : Using FFT algorithm DFT of discrete noisy ECG h(n) sampled into n point and discrete noisy ECG signal h(n).
Using FFT algorithm DFT of discrete ECG signal h(n) (N sample, at t=n ,h(t)=h(n)) is defined as

$$X(k) = \sum_{n=0}^{N-1} h(n)\, W_N^{nk}, \quad 0 \le k \le N-1 \tag{7}$$

X(k) is defined as how the amplitude changes over frequency. To obtain the noisy ECG signal for statical results. Time series h(t) is windowed (or multiplied point to point) with window function (Gaussion function) g(t) then resulting spectrum is

$$H(f) = \int_{-\infty}^{\infty} h(t)\, e^{-i2\pi ft}\, dt \tag{8}$$

Genearrlied Gaussaion function

$$g(t) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-t^2}{2\sigma^2}} \tag{9}$$

taking window width σ to proportion to inverse of frequency

$$\sigma(f) = \frac{1}{|f|} \tag{10}$$

DFT of noisy ECG signal h[kT] is given by

$$X\left[k, \frac{m}{NT}\right] = \sum_{n=0}^{N-1} H\left[\frac{K+m}{NT}\right] e^{\frac{-2\pi^2 m^2}{n^2}} e^{\frac{i2\pi mj}{N}} \tag{11}$$

Where H $[\frac{m}{HT}]$ is fourier transform of frequency domain noisy ECG signal shown in fig.2 (a) is h[kT] with 154 selected frequency at 1.25 dB SNR level.

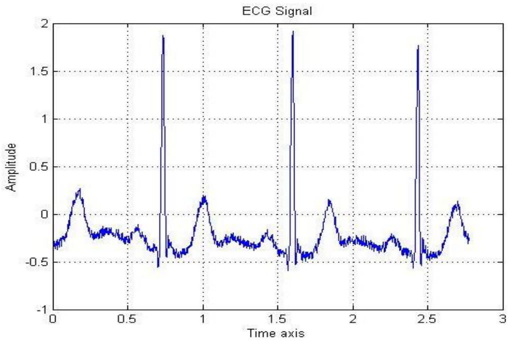

Fig.2 (a) Noisy ECG signal

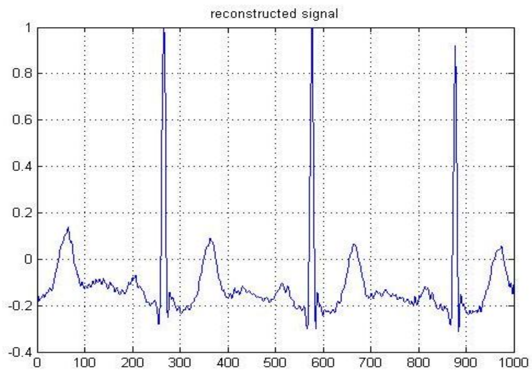

Fig.2 (b) Reconstructed ECG signal

Step 2: Appling frequency domain thresholding high frequency noise removed because ECG signal concentrated between band 0.05 - 100 Hz frequency. Therefore frequency below 200 Hz retain by frequency thresholding.
Step 3: Masking and Filtering is done to remove noise between QRS complex of frequency domain by staticaly appropriate threshold.
Step 4: Taking IFFT of the filterd signal of step 3, reconstructed time domain ECG signal obtain and show in fig.2 (b).

4. Result and discussion

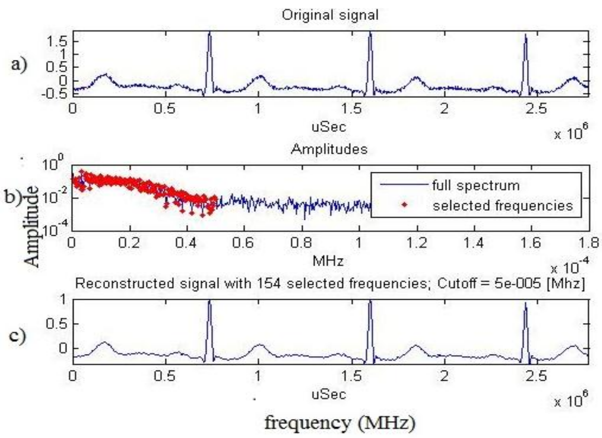

Fig 3 (a) standard ECG signal available at MIT-BIH online database (b) noisy ECG signal (c) Reconstructed ECG signal using FFT

Fig. 3 (a), (b) and (c) shows the experimental result in which fig3. (a) is the standard ECG signal fig3.(b) is the noisy ECG signal. Noise added to selected region marked in the graph. for the section of 0.5 Mhz and fig3.(c) shows the reconstructed signal of ECG after denoising through proposed methodology.

Standard signal and noisy signal show in fig.3 (a) and fig.3 (b) available at online MIT-BIH Arrhythmia database. This data base contains 48 ECG signal 30 min. duration which sampled at 360 Hz, an artificial noise is added to this signal that results 0dB, 1.25dB and .5dB SNR proposed methodology is to test denoising these noise signal and compared with other commonly used denoising method of ECG signal.

In this paper an artificial white Gaussian noise added to the standard ECG signal shown in fig3 (b) and it is represented the channel noise in the ECG signal while transporting ,for the duration of 0.5 Mhz frequency shown in fig 3 (b) by dotted spectrum .The channel noise introduced into the signal due to the poor channel condition and same can be modelled by white Gaussian noise which all frequency components, after adding artificial Gaussian noise at 1.25dB, a portion of distorted signal in the duration 0.5 MHz.

The proposed method reconstructs the signal and check the accuracy by two factor SNR and RMSE from the result obtain the help of MATLAB version (7.9.0.529) at window 7 platform. The proposed method gives better performance with higher SNR of 12.07dB and lower RMSE is 0.269, the reconstructed signal shown in the fig 3 (c).

Performance comparison with WT and S-transform

Table 1 comparison of SNR and RMSE of various techniques

MIT-BIH Tape no.103	WT	S-transform	FFT
SNR	6.72	10.95	12.07
RMSE	0.461	0.284	0.269

Table no 1 shows that comparison between various techniques wavelet transform, S-transform , and proposed method (FFT) ,result shows that the higher SNR (12.07dB) and lower RMSE (0.269dB) which is desirable for any signal therefore proposed method(FFT) Fast Fourier transform is more suitable than any other commonly used method .

Conclusion and future aspect

It can be concluded from experimental result and variance (ANOVA) based statistical method, proposed FFT algorithm based DFT method of enhancement of channel noise embedded with ECG signal shows better performance.

Showing higher SNR and low RMSE from generally used techniques used to ECG signal enhancement .ECG signal required to accurate analysis of heart condition therefore proposed method may play vital role in analysis of ECG signal and diagnosis of heart diseases.

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