The Combined Effect of Median and FIR Filter in Pre-processing of ECG Signal using Matlab

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ABSTRACT

The ECG (Electrocardiogram) signal is continuous in nature and abruptly changing. For taking intelligent health care decisions related with heart diseases such as paroxysmal of heart, arrhythmia diagnosing, ECG signal needs to be pre-process accurately for the further action on it such as extracting the features, wavelet decomposition, distribution of QRS complexes in ECG recordings and related information such as heart rate and RR interval, classification of the signal by using various classifiers etc. Digital filters plays very significant role in the analysis of the low frequency components in ECG signal. Numbers of biomedical signals are of low frequency, the removal of baseline wander and power line interference is a very important step at the pre-processing stage of ECG. This paper deals with the study of FIR (Finite Impulse Response) filtering and Median Filtering of ECG signals under noisy condition. The results shows that the combination of Median and FIR filter for the pre-processing of ECG signal is more beneficiary and effective for the later analysis.

Keywords

ECG, FIR filter, Median filter, Pre-processing.

1. INTRODUCTION

Electrocardiography is a transthoracic interpretation of the electrical activity of the heart over a period of time, as detected by electrodes attached to the outer surface of the skin and recorded by a device external to the body [1]. The recording produced by this noninvasive procedure is termed as electrocardiogram (also ECG or EKG). An ECG test records the electrical activity of the heart.

ECG is used to measure the rate and regularity of heartbeats, as well as the size and position of the chambers, the presence of any damage to the heart, and the effects of drugs or devices used to regulate the heart, such as a pacemaker.

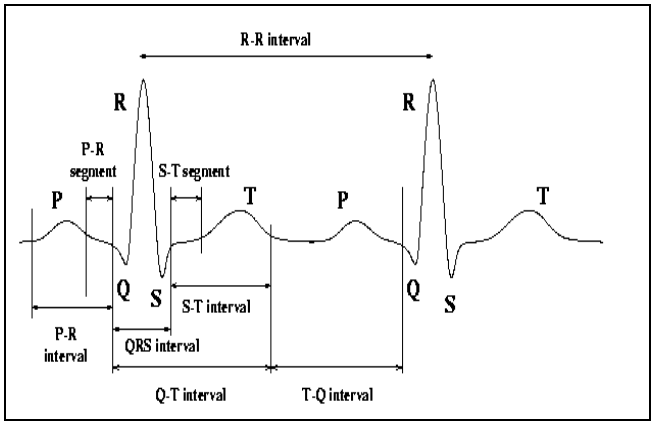

Fig.1 - ECG Waveform

Fig.1 shows an ECG Waveform which consist of P wave, QRS complex, T wave and various intervals. Importantly, the R-R interval represents one heartbeat.

While acquisition of ECG, it gets corrupted due to different types of artifacts and interferences such as Power line interference, Electrode contact noise, Motion artifacts, Muscle contraction, Base line drift, Instrumentation noise generated by electronic devices and Electrosurgical noise. For the meaningful and accurate detection, steps have to be taken to filter out all these noise sources. The EMG is high frequency fluctuation is due to the random depolarization and contraction of cardiac muscles while abrupt transitions are due to random moment of the body. The base line wandering, a low frequency fluctuation is due to the rhythmic depolarization and repolarization during respiration [9]. Hence, FIR and Median filters are discussed in this paper and how they can be applied in combination on vital signal of human body that is ECG for heart care is depicted. Section 2 discusses Material samples of ECG used for the experiments. FIR and Median filters are described in section3. Section 4 depicts how these filters can be applied on ECG signal for pre-processing and some of the results after applying filters. Section 5 represents Conclusion.

2. MATERIAL

In this pre-processing, the samples of ECG recordings of different patients were used for study cases. These ECG recordings were collected from MIT-BIH database distribution. It is easy to analysis those ECG recordings in

Matlab. The number of samples is not enough for a complete research concerning the effects of age, gender, weight, etc. Because the purpose of this study focuses only on the pre-processing of ECG signal, these factors, such as age, gender, and weight, etc. are not concern factors for sampling.

3. FILTERS

3.1 Median Filter

The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing. The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. The pattern of neighbors is called the "window", which slides, entry by entry, over the entire signal. For 1D signals, the most obvious window is just the first few preceding and following entries, whereas for 2D (or higher-dimensional) signals. Purpose of digital median filter is smoothing signals by taking the median of odd number of continuous sampling points [6]. The median filter thus uses both past and future values for predicting the current point.

y = medfilt1(x, n, blksz, DIM)

MEDFILT1 is One dimensional median filter. Y = MEDFILT1(X, N) returns the output of the order N, one dimensional median filtering of X. Y is the same size as X; for the edge points zeros are assumed to the left and right of X. If X is a matrix, then MEDFILT1 operates along the columns of X. If N is not specified, MEDFILT1 uses a default of N = 3.
*For N odd, Y(k) is the median of X(k-(N-1)/2 : k+(N-1)/2).
*For N even, Y(k) is the median of X(k-N/2 : k+N/2-1).

3.2 FIR Filter

FIR filters are widely used due to the powerful design algorithms that exist for them, their inherent stability when implement in non-recursive form, the ease with which one can attain linear phase, their simple extensibility to multi rate cases, and the ample hardware support that exists for them among other reasons. In order to determine a suitable filter order, it is necessary to specify the amount of passband ripple and stopband attenuation that will be tolerated. It is also necessary to specify the width of the transition region around the ideal cutoff frequency. The latter is done by setting the passband edge frequency and the stopband edge frequency. The difference between the two determines the transition width.

There are essentially three well-known methods for FIR filter design namely:

1. The window method
2. The frequency sampling technique
3. Optimal filter design methods

The window method uses following functions and parameters.

[b, a] = fir1(N, Wn, varargin)

B = FIR1(N, Wn) designs an N'th order lowpass FIR digital filter and returns the filter coefficients in length N+1 vector B. The cut-off frequency Wn must be between 0 < Wn < 1.0, with 1.0 corresponding to half the sample rate. The filter B is real and has linear phase. The normalized gain of the filter at Wn is -6 dB.

B = FIR1(N,Wn,'high') designs an N'th order highpass filter. We can also use B = FIR1(N,Wn,'low') to design a lowpass filter. If Wn is a two-element vector, Wn = [W1 W2], FIR1 returns an order N bandpass filter with passband W1 < W < W2. We can also specify B = FIR1(N, Wn, 'bandpass'). If Wn = [W1 W2], B = FIR1(N, Wn, 'stop') will design a bandstop filter.

For filters with a gain other than zero at Fs/2, e.g., highpass and bandstop filters, N must be even. Otherwise, N will be incremented by one. In this case the window length should be specified as N+2.

4. RESULT

An objective of a health process is one where patients can stay healthy with the support of expert medical advice when they need it, at any location and any time. An associated aim would be the development of a system which places increased emphasis on preventative measures as a first point of contact with the patient. As the vital signal such as ECG plays key role for predicting health status of a human, and these signals are continuous in nature, we propose to apply FIR and Median filters for pre-processing on ECG signal. The original signal having ECG input up to 100 seconds is shown in figure 2. The sample results are shown in figure 3, for ECG signal after applying Median filter only and in figure 4, ECG signal is pre-process by applying FIR filter only. We propose to apply both these filters simultaneously on ECG signal for effective further analysis which is shown in figure 5.

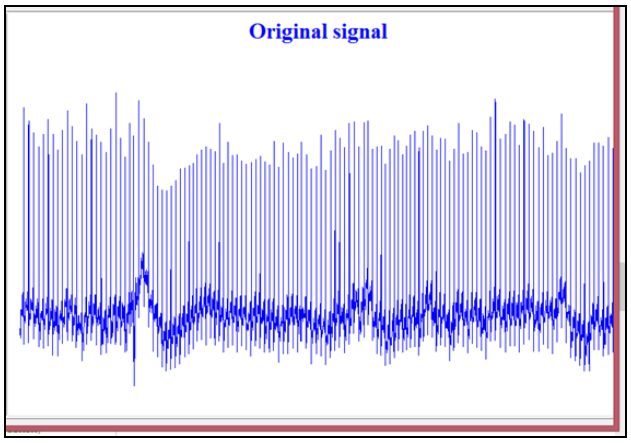

Fig. 2 Original ECG signal

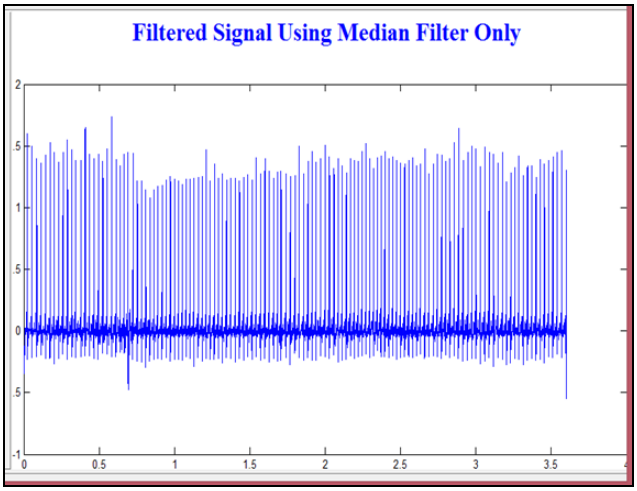

Fig. 3 Filtered ECG signal using Median filter only

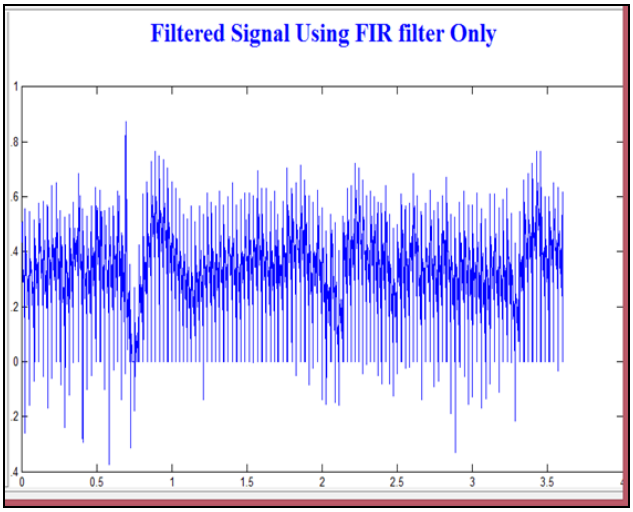

Fig. 4 Filtered ECG signal using FIR filter only

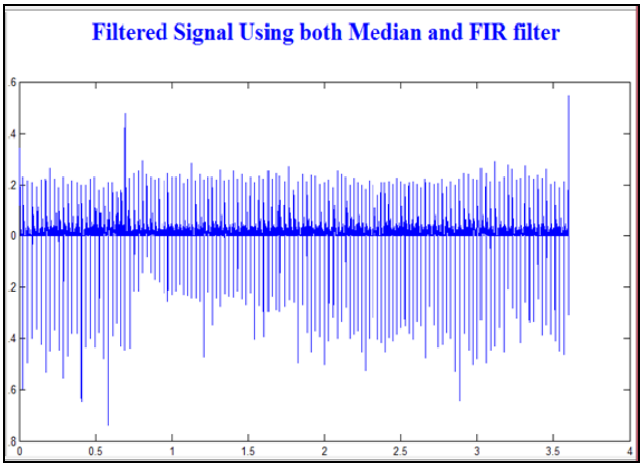

Fig. 5 Filtered ECG signal using both Median and FIR filter

5. CONCLUSION

In this study our main objective is to demonstrate the combined effect of Median and FIR filter for the pre-processing of an ECG signal which is more significant and very efficient rather than using single filter. This combination of FIR and Median filter in pre-processing an ECG signal removes not only baseline drift (drift refers to the deviation of the signal from one state to another unpredictable state) but also preserves edges while removing noise. Another motivation for this type of work to perform for ECG signal because pre-processing is a vital step for later and better analysis of ECG signal of human being to take accurate decision regarding heart diseases.

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