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Research paper

Denoising of Ecg Signals Using Fir & Iir Filter: a Performance Analysis

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Abstract

Electrocardiogram (ECG) signal is the electrical recording of coronary heart activity. It is a common routine and vital cardiac diagnostic tool in which in electric signals are measured and recorded to recognize the practical status of heart, but ECG signal can be distorted with noise as, numerous artifacts corrupt the unique ECG signal and decreases it quality. Consequently, there may be a need to eliminate such artifacts from the authentic signal and enhance its quality for better interpretation. ECG signals are very low frequency signals of approximately 0.5Hz-100Hz and digital filters are used as efficient approach for noise removal of such low frequency signals. Noise may be any interference because of movement artifacts or due to power device that are present wherein ECG has been taken. Consequently, ECG signal processing has emerged as a common and effective tool for research and clinical practices. This paper gives the comparative evaluation of FIR and IIR filters and their performances from the ECG signal for proper understanding and display of the ECG signal.

Keywords: *Baseline Noise; ECG; FIR Filter; IIR Filter; Noise.*

1. Introduction

Heart associated illnesses are a few of the essential causes of human deaths everywhere in the world. Therefore, to apprehend the physiological and practical fame of heart, an efficient tools and techniques for effective prognosis of the cardiac ailment are needed. Electrocardiography (ECG) is a tool extensively used to apprehend the condition of the heart. Now-a-days, computerized ECG evaluation is considered as a primary and reliable technique for the prognosis of cardiac related illnesses. The ECG recordings received by means of setting electrodes on the subject's chest and limbs get contaminated with specific kinds of artifacts which includes power line interference, Baseline drift, movement artifacts, Electrode contact noise, Instrumentation noise because of electronic gadgets, amongst unique noises, the noise from electric power device is a prime source of noise throughout the recording or monitoring of ECG. Exclusive noises have unique frequencies; the noise with low frequency creates problem with ECG signal and a while high frequency noises additionally interfere ECG i.e. cellular smartphone. The frequency is measured in cycle/second or in "Hertz". As an instance the electric power utilized in daily life is 50 Hz in India [3]. In this paper, the principle aim is to eliminate the noises of the electrocardiogram (ECG) using FIR and IIR filters. Because of Baseline noise interference, it becomes hard to research the ECG records either manually or by way of automatic means.

2. Digital Filters

Digital filter is a mathematical algorithm implemented in hard ware and software. Digital input signal is produce a digital output signal for purpose of achieving a filter objective. A digital filter is used for two general purposes: (i) Separation of signal that have been combined and (ii) restorations of signal that have been distorted in some way signal separations needed when signal has been contaminated with interference, noise, or other signal.

Filters may be:

- Linear or non-linear.
- Time-invariant or time-variant.
- Causal or non-causal.
- Analog or Digital.
- Discrete-time (sampled) or continuous-time.
- Passive or active type of continuous-time filter
- Infinite impulse response (IIR) or finite impulse response (FIR) type of discrete-time or digital filter.

3. Methodology

Filter can be implemented either in software as a program, or hardware as a circuit. For our simulation purpose, MATLAB is necessary and effective software to attain the convincible results. MATLAB has some advantages compared with conventional computer languages for technical problem solving. Among them are following [6].

- Predefined Functions.
- Platform Independence.
- MATLAB compiler ease of use.
- Graphical user interface,
- Device Independent plotting.

In the implementation procedures firstly, the ECG signal from the database is loaded into the MATLAB. Then, the simulated signal is added to the loaded signal. Then the original ECG signal and the noise added ECG signal are examined in time domain and the suitable design parameters for different digital filters.

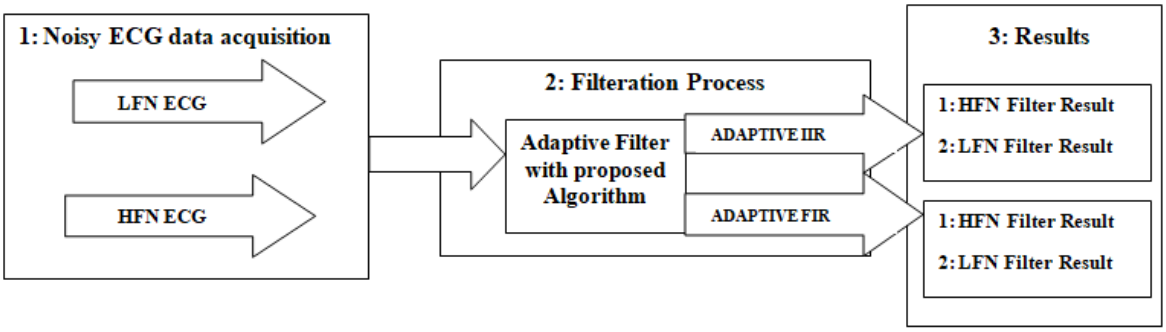

Fig. 1: Step Wise Methodology for Filteration Process

4. Algorithm Used

The proposed algorithm can be motivated and derived as the exact solution to a well-defined estimation problem with a least-squares cost function. Some algorithm like LMS adaption algorithm has slow convergence property due to which it is not able to work on s fast varying signal and not be suitable to observe the accurate value of the step size μ. To minimize the problem a new algorithm is proposed. This method is mostly used in noise cancellation and real time system because it has a fast convergence and high magnitude as compare to the other algorithms. In which it used the information of the input data, it reverts the developed information when the proposed method is introduce on the spot. The arrival new data is used to calculate the tap weight vector at time (n-1) and updated vector at time n.

For 1 to n = Final

i. Get $x[n], y[n]$

ii. Get $e[n] = x[n] - h'[n-1]y[n]$

iii. Calculate Gain vector

$$K[n] = \frac{P[n-1]y[n]}{\lambda + y[n]P[n-1]y[n]}$$

iv. Update the filter Parameters

$$h[n] = h[n-1] + k[n]e[n]$$

v. Update the P matrix

$$P[n] = \frac{1}{\lambda}(P[n-1] - K[n]y[n]P[n-1])$$

end

5. Results

This paper presents the results of simulation using MATLAB to investigate the performance behaviors of FIR and IIR filter with and without noise on the various parameters.

5.1 Noise Removal Results for FIR & IIR Filters

To verify the algorithm suggested in this paper, the ECG signals were filtered and evaluated the overall error of the signal and the optimal filter order. In this paper, MATLAB was used to estimate the performance of the proposed filters & experimented with two kinds of filters.

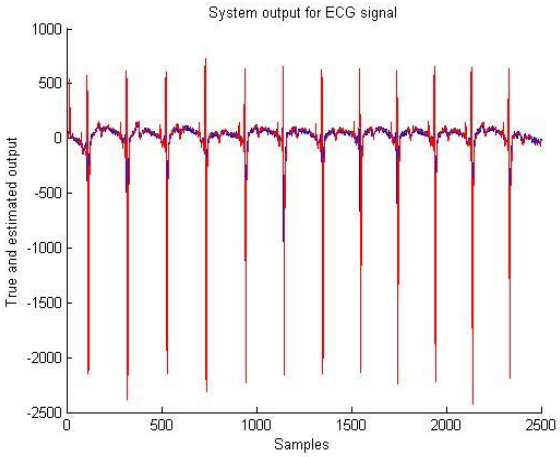

Fig.2: System Output of FIR Filter (Without Noise in ECG Signal)

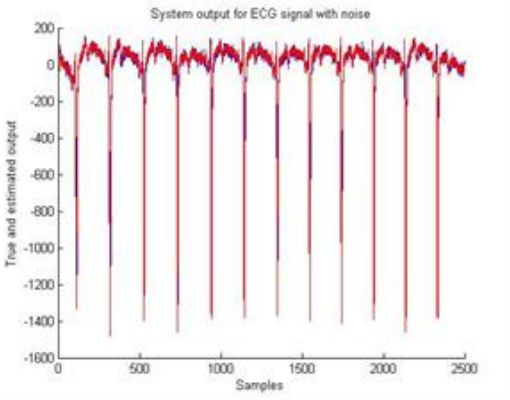

Fig. 3: System Output of FIR Filter (With Noise in ECG Signal)

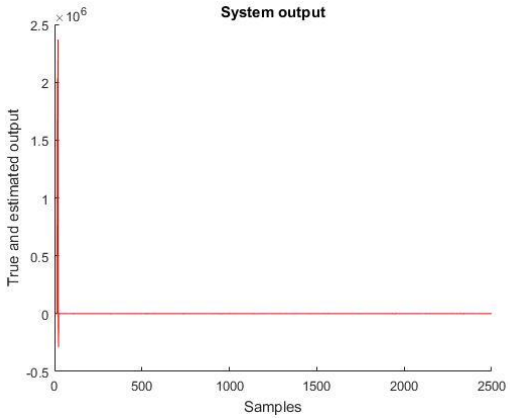

Fig. 4: System Output of IIR Filter
(Without Noise in ECG Signal)

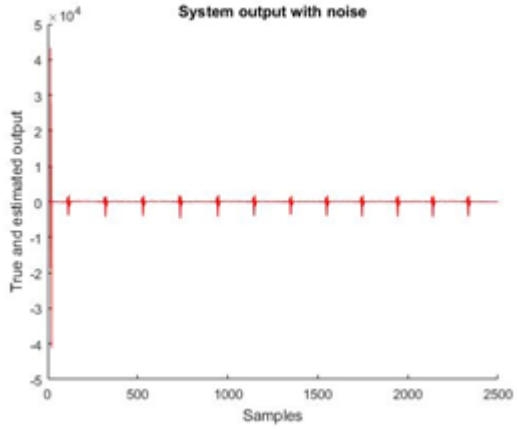

Fig. 5: System Output of IIR Filter
(With noise in ECG signal)

5.2 Error calculation results for FIR & IIR filters

Figure 6,7,8,9 shows the error curve which are plotted using MATLAB respectively for FIR and IIR filters. A logarithmic scale is used for the calculation & plotting of curves as it can show minor difference too in the spectrograms. By plot we can see easily that the high frequency components are suppressed much with the help of FIR rather than IIR filter**.**

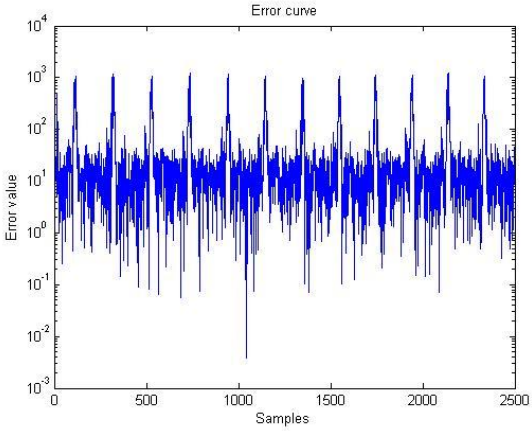

Fig. 6: Error Curve for FIR Filter
(Without Noise in ECG signal)

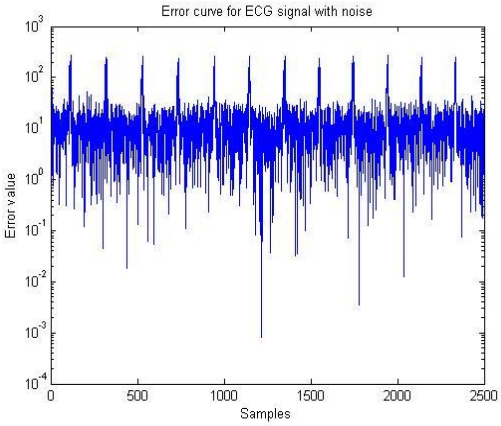

Fig. 7: Error Curve for FIR Filter
(With Noise in ECG signal)

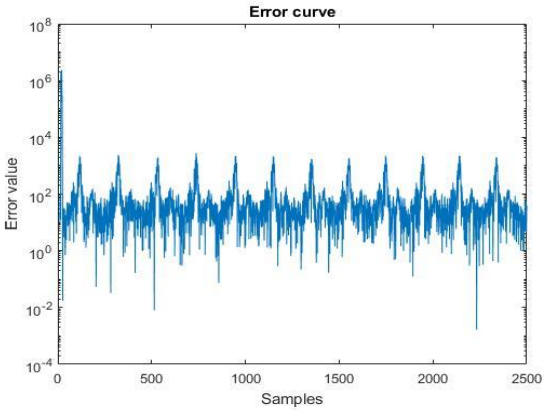

Fig. 8: Error Curve for IIR Filter
(Without Noise in ECG signal)

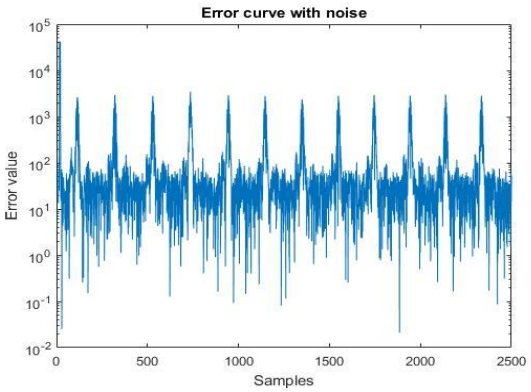

Fig. 9: Error Curve for IIR Filter
(With Noise in ECG signal)

5.3 Comparison of the Filter Weights and Estimated Weights

According to the order of the filter the following figures shows a comparison between the filter weights and estimated weights for both FIR and IIR filters. As per the assumption the FIR filter has lower order than the IIR filter because FIR filter output is calculated using the current and past input, but not previous values of the output and produce more placental results at the selected order but IIR filters are recursive filters that use the surrounding input and previous output values together and the selected order introduce good results.

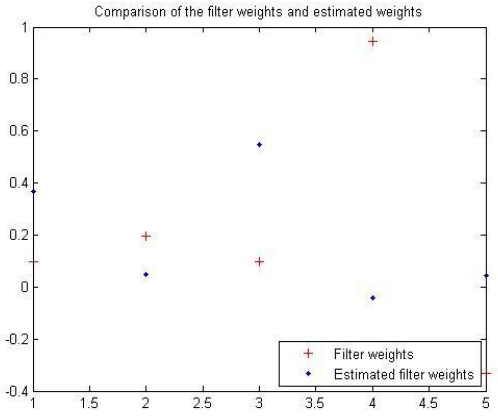

Fig. 10: Comparison of FIR Filter Weights & Estimated weights (Without Noise in ECG Signal)

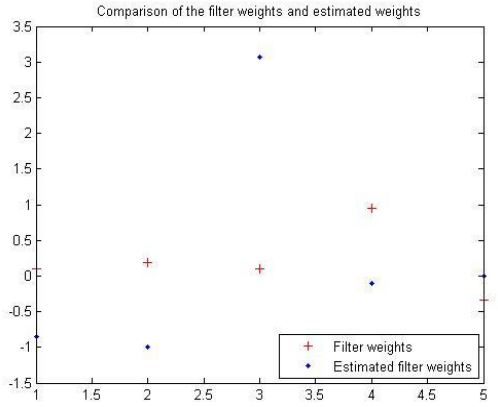

Fig. 11: Comparison of FIR Filter Weights & Estimated weights (With Noise in ECG Signal)

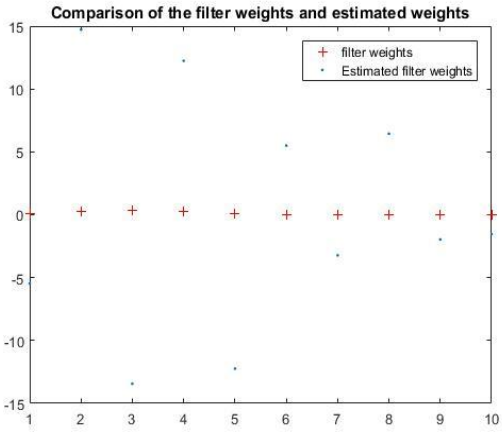

Fig. 12: Comparison of IIR Filter Weights & Estimated weights (Without Noise in ECG Signal)

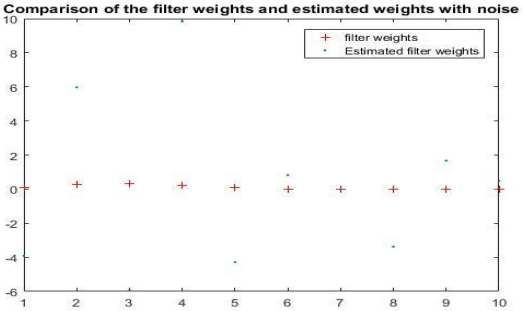

Fig. 13: Comparison of IIR Filter Weights & Estimated weights (With Noise in ECG Signal)

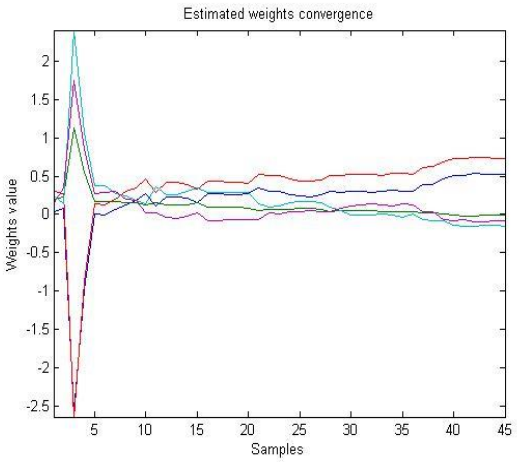

Fig. 14: Estimated Weight Convergence of FIR Filter with Noise

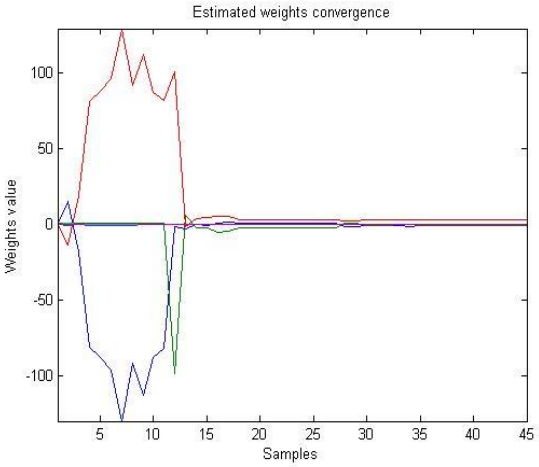

Fig. 15: Estimated Weight Convergence of FIR Filter without Noise

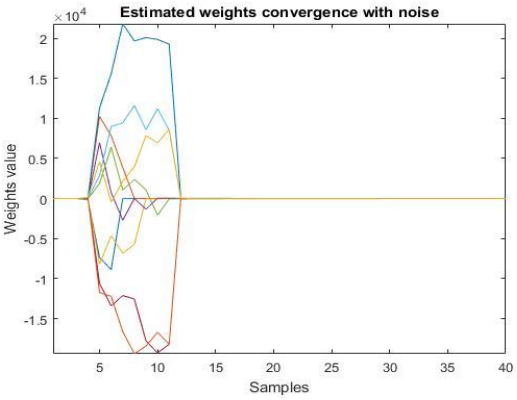

Fig. 16: Estimated weight convergence of IIR Filter with Noise

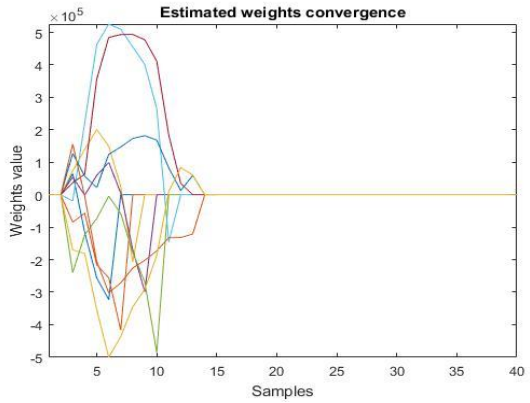

Fig. 17: Estimated weight Convergence of IIR Filter without Noise

6. Conclusion

Electrocardiogram is the commonly used signal in the field of biomedical. ECG signal is corrupted by different types of noises such as High Frequency Noise & Low Frequency Noise. The algorithm which is used in this paper can improve the performance of filtering for these types of signals. In this paper FIR and IIR filter used for the removal of High Frequency & Low Frequency noise. The output of the FIR filter is very near about the desired value & has small removal of High Frequency Noise & Low Frequency Noise while the output which we get through IIR filter has less value than the desired output. Another important conclusion which we get through the observation is this that the standard deviation of IIR filter is much closer to the desired output & the standard deviation of the FIR filter output with high frequency noise have less value than the IIR filter. The results which are given by FIR filter for proposed algorithm have much accurate results compared with IIR filter.

7. Scope & Future Work

The objective of this paper is to analyze and compared different filters for ECG Signals. The results show that FIR filter is more stable than IIR filters. Thus, noise removal using FIR digital filter is better option in comparison with IIR digital filter. In this paper, only FIR and IIR Filter is compared on two parameters, they can analyze on more parameters in future, further the results can be compared with other Filters.

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