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Filtering Techniques of ECG Signal Using Fir Low Pass Filter with Various Window Techniques

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Abstract

ECG is the graphical recording of the electrical activity of the heart and recognized biological signal used for clinical diagnosis. The ECG signal is very sensitive in nature, and even if small noise mixed with original signal the various characteristics of the signal changes. Filtering of ECG signal is very important because noisy ECG signal can mask some important features of the Electrocardiogram (ECG). Hence it is desirable to reduce this noise for proper analysis of the ECG signal. This paper presents the study of FIR filter using window techniques for ECG signal Processing. The parameters i.e. Power Spectral Density (PSD), average power and signal to noise ratio (SNR) are calculated of ECG signal and compare the performance of different window methods used for FIR filter. One more algorithm called as Peak detection algorithm is also implemented which has shown very good efficiency in smoothing out the waveform and suppressing line noise. For the implementation of this proposed work we use the Image Processing Toolbox under Matlab software.

Keywords: Finite Impulse Response (FIR), Low–Pass Filter, ECG Data Signal, FIR filter, Power Spectrum Density (PSD), Signal to Noise Ratio (SNR).

Introduction

Electrocardiogram (ECG) consists of graphical recording of electrical activity of the heart over time. It is most recognized biological signal, and with non- invasive method; it is commonly used for diagnosis of some diseases by inferring the signal. Cardiovascular diseases and abnormalities alter the ECG wave shape; each portion of the ECG waveform carries information that is relevant to the clinician in arriving at a proper diagnosis. The electrocardiograph signal taken from a patient is generally get corrupted by external noises, hence necessitating the need of a proper noise free ECG signal. A signal acquisition system, consist of several stages, including: signal acquisition though hardware and software instrumentation, noise or other characteristics filtering and processing for the extraction of information. Electrocardiography signals recorded on a long timescale (i.e., several days) for the purpose of identifying intermittently occurring disturbances in the heart rhythm. It is a combination of P, T, U wave, and a QRS complex. The complete waveform is called an electrocardiogram with labels P, Q, R, S, and T indicating its distinctive features.

Mohandas Choudhary, Ravindra Pratap Narwaria in 2011. He proposed Suppression of Noise in ECG Signal Using Low pass IIR Filters. In Diagnosing of ECG Signal, Signal acquisition must be noise free. Experienced physicians are able to make an informed medical diagnosis on heart condition by observing the ECG signal. This paper deals the application of the digital IIR filter on the raw ECG signal. In this paper Butterworth, Chebyshev Type-I and Chebyshev Type-II filter are utilized. At the end all these filter types are compared. In this paper using 222txt ECG data set from MIT-BIH arrhythmia database. The results obtained from Butterworth filter, Chebyshev Type-I and Chebyshev Type-II are compared on the basis of signal to noise ratio and average power. It is forward that Butterworth low pass filter removes more noise. Seema Nayak Dr. M. K. Soni Dr. & Dipali Bansal in 2012, proposed FILTERING TECHNIQUES FOR ECG SIGNAL PROCESSING. ECG is the graphical recording of the electrical activity of the heart and recognized biological signal used for clinical diagnosis. The ECG signal is very sensitive in nature, and even if small noise mixed with original signal the various characteristics of the signal changes. The signal voltage level is as low as 0.5 to 5mV and is susceptible to artifacts that are larger than it. The frequency components of a human's ECG signal fall into the range of 0.05 to 100Hz and as far as the noise is concerned; the muscle movements, mains current

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and ambient electromagnetic interference generate it. Hence filtering remains an important issue, as data corrupted with noise must either filter or discarded. Prakruti J. Joshi, Vivek P. Patkar, Akshay B. Pawar in 2013. He proposed ECG Denoising Using MATLAB. At present many of the ECG recording instruments are based on analog recording circuitry. Due to this, noises from various sources are inherently added to the signal. Sometimes power of noise becomes even larger than the signal. In this study various sources of noise that usually corrupt the ECG signal are identified and attempt is made to get rid of such noises. Various filtration techniques such as low pass filter, high pass filter, band pass filter and notch filter are used to filter the signal from noises. One more filter called as moving averaging filter is also implemented which has shown very good efficiency in smoothing out the waveform and suppressing 50 Hz Power line noise. The design of the filters indicates that there are some ripples in the filters but the responses are stable.

The remainder of this paper is organized as the following. At first, in Section II we illustrate the various components of our proposed technique to Filtering Techniques of ECG Signal Using Fir Low Pass Filter with Various Window Techniques. Further, in Section III we present some key experimental results and evaluate the performance of the proposed system. At the end we provide conclusion of the paper in Section IV and state some possible future work directions.

Proposed technique

This section illustrates the overall technique of our proposed filtering techniques of ECG signal using fir low pass filter with various window techniques. In this paper, we proposed 'Filtering Techniques of ECG Signal Using Fir Low Pass Filter with Various Window Techniques using Peak detection algorithm'. The application of low pass filter for removal of high frequency signals from the ECG using digital FIR filters designed with window technique is described in the present section. Three different types of windows were used namely Hamming window, Hanning window and Kaiser Window. The low pass filters were designed by using different windows. Order of the filter is 100 and sampling frequency is 1000Hz. When FIR filter is designed using window of the order of 100. Design of high pass filter using windows methods to face the problem of base line wonder in the ECG signal is described in this section. Different windows namely Hamming window, Hanning window and the Kaiser Window ware used to design the high pass filter. The high pass filter was designed using window function. The order of filter was 100 and sampling frequency 1000Hz. By using the FDA tool set the parameter low pass Fir filter with minimum order with the cutoff frequency. The main objective of this implementation is given:

- Removal of noises from ECG signal is a classical problem and many researchers work on signal noise removing by different filtering method and algorithms. We proposed Filtering Techniques of ECG Signal Using Fir Low Pass Filter with Various Window Techniques using Peak detection algorithm.
- The parameters i.e. Power Spectral Density (PSD), average power and signal to noise ratio (SNR) are calculated of ECG signal and compare the performance of different window methods used for FIR filter.
- The filtering techniques are primarily used for preprocessing of the signal and have been implemented in a wide variety of systems for ECG analysis. Filtering of the ECG is contextual and should be performed only when the desired information remains ambiguous.
- We used a Kaiser Window FIR high pass filter to remove the baseline wandering. They found that there are still other types of noise, which still affect the ECG signal, after removing baseline wandering.
- Application of the window function is difficult task. Difficulties in theoretical design of the filter become easier in the design using Matlab.
- The biomedical signal in the present work is the ECG signal and the filtering technique suggested is using FIR with Kaiser Window. This ECG gets corrupted due to different kinds of the artifacts. The different types of artifacts are Power line interference, motion artifacts, base line drift and instrumental noise.

A. ECG SIGNAL PROCESSING

Signal processing is performed in the vast majority of systems for ECG analysis and interpretation. It is used to extract some characteristic parameters. Now a day's biomedical signal processing have been towards quantitative or the objective analysis of physiological systems and phenomena via signal analysis. The field of biomedical signal analysis or processing has advanced to the stage of practical application of signal processing and pattern analysis techniques for efficient and improved non invasive diagnosis, online monitoring of critical ill patients, and rehabilitation and sensory aids for the handicapped. The objective of

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ECG signal processing is manifold and comprises the improvement of measurement accuracy and reproducibility. ECG analysis concerns resting ECG interpretation, stress testing, ambulatory monitoring, or intensive care monitoring, which forms a basic set of algorithms that conditions the signal with respect to different types of noise and artifacts, detect heartbeats, extract basic ECG measurements of wave amplitudes and durations, and compress the data for efficient storage or transmission.

The basic ECG has the frequency range from 0.5Hz to 100Hz. artifacts removal plays the vital role in the processing of the ECG signal. It becomes difficult for the specialist to diagnose the diseases if the artifacts are present in the ECG signal.

B. TYPES OF ARTIFACT IN ECG SIGNAL

The objectives of acquisition of ECG signal and signal processing system is to acquire the noise free signal. The major sources of noise are

1. Power line interference
2. Muscle contractions
3. Electrode contact noise
4. Motion Artifacts
5. Baseline wandering
6. Noise generated by electronic devices used in signal processing circuits
7. Electrical interference external to the subject and recording system
8. High-frequency noises in the ECG
9. Breath, lung, or bowel sounds contaminating the heart sounds (PCG).

There are various types of methods to extract the ECG parameters from the noisy ECG signal. First we need to analyze ECG signal to get which type of noise mesh up with the signal.

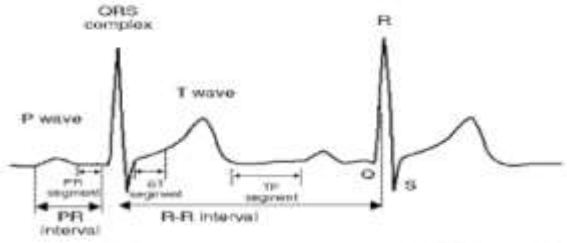

Fig.-1 Schematic representation of ECG signal

C. ECG FILTERING

The filtering techniques are primarily used for preprocessing of the signal and have been implemented in a wide variety of systems for ECG analysis. Filtering of the ECG is contextual and should be performed only when the desired information remains ambiguous. Many researchers have worked towards reduction of noise in ECG signal. Most types of interference that affect ECG signals may be removed by band pass filters; but the limitation with band pass filter is discouraging, as they do not give best result. At the same time, the filtering method depends on the type of noises in ECG signal. In some signals the noise level is very high and it is not possible to recognize it by single recording, it is important to gain a good understanding of the noise processes involved before one attempt to filter or preprocess a signal. The ECG signal is very sensitive in nature, and even if small noise mixed with original signal the characteristics of the signal changes. Data corrupted with noise must either filtered or discarded, filtering is important issue for design consideration of real time heart monitoring systems. The electrocardiogram (ECG) is a non-invasive test that records the electrical activity of the heart over time and it is very useful in the investigation of heart disease, for example a cardiac arrhythmia. In recording an ECG signal is frequently corrupted with different types of electrical and mechanical noises such as 50/60Hz power line interference (50 Hz noise the frequency coming from the power supply in many countries), baseline drift, electrode movement and motion artifact, white noise, etc. Hence, removal of artifacts in ECG signal is as a pre-processing operation in most analysis of disease diagnosis and clinical applications. In the effort to remove these noises, there has been little success when employing traditional methods such as linear filers, signal averaging, and their combination. Recently, adaptive and non adaptive filter have been developed as one of the most common and effective tools in processing and analysis of biomedical signals such as ECG. It can be recorded by electrodes placed on the surface of body. We present the implementation of FIR filter with various window techniques, base of this paper we are study to other window function and comparison to the Kaiser Window techniques for enhancement of ECG signal using Peak detection algorithm.

D. Kaiser Window

In this window the side lobe level can be controlled by with respect to the main lobe peak by varying a parameter α. Kaiser Window parameter β affects by side lobe attenuation α db. The width of main lobe can be varied by adjusting the length of the filter.

$$\beta = \begin{cases} 0.1102(\alpha - 8.7), \alpha > 50 \\ 0.582(\alpha - 21)^{0.4} + .07886(\alpha - 21), 21 \le \alpha \le 50 \\ 0, \alpha < 21 \end{cases} \quad (4)$$

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Where α = -20log10δ is the stop band attenuation in db. Increasing β then decreases the amplitude of side lobe. Filter order for FIR filter is

$$N = \frac{\alpha - 8}{2.285\Delta\omega} + 1 \quad \text{.....[5]}$$

Here N is the filter order and Δω is the width of the smallest transition region.

E. Hanning window

The coefficient of a Han window is calculated from the following equation.

$$\omega(n) = \begin{cases} 0.5 - 0.5\cos\left(\frac{2\pi n}{N}\right), 0 \le n \le M-1 \\ 0, \text{otherwise} \end{cases} \quad \text{.....[6]}$$

The width of main lobe is approximately 8π/M and peak of first side lobe is at – 32dB [12].

Evaluation and results

To verify the effectiveness (qualities and robustness) of the proposed filtering techniques of ECG signal using fir low pass filter with various window techniques, we conduct several experiments with this procedure on several ECG signal sample. There are some steps of our proposed technique are given below:

Phase 1: Firstly we develop a particular GUI for this implementation. After that we develop a code for the loading the input ECG data in the Matlab database.

Phase 2: Develop a code for the smoothing the input ECG data. After that we got the smooth ECG signal.

Phase 3: Develop a code for add noise in ECG signal.

Phase 4: After that we develop code different type of filtering technique.

Flow Chart of proposed method:

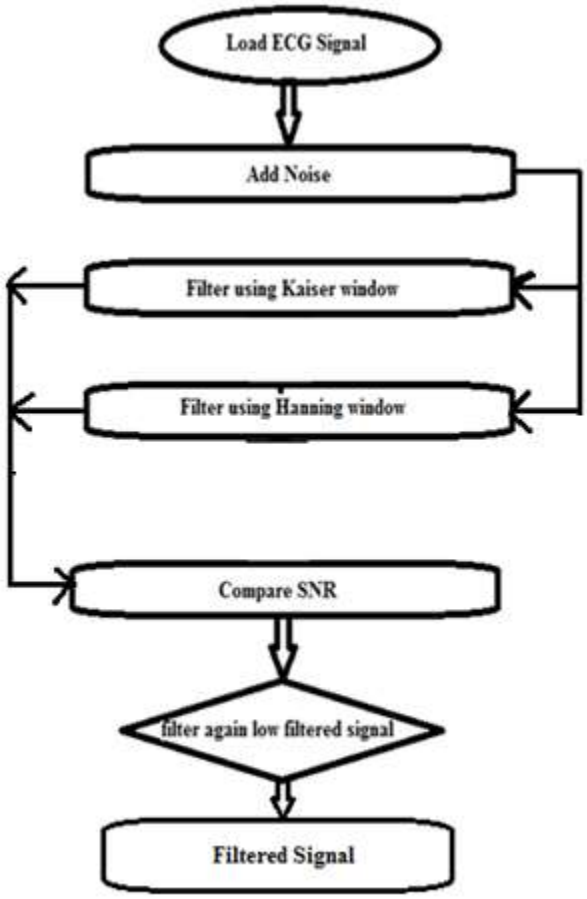

Figure: 1. Flow chart of proposed method

Evaluation & Results

In this paper we present Filtering Techniques of ECG Signal Using Fir Low Pass Filter with Various Window Techniques using Peak detection algorithm. Result and analysis of our proposed work is given below:

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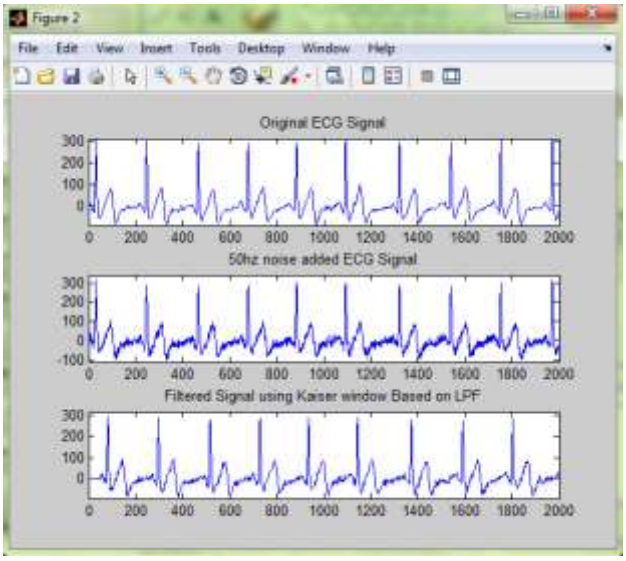
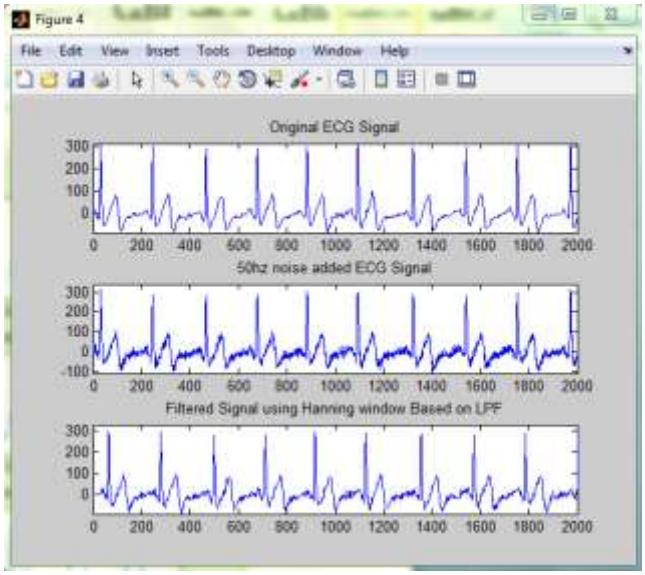
Figure: 2. Work window of model





Conclusion

In this paper, we present Filtering Techniques of ECG Signal Using Fir Low Pass Filter with Various Window Techniques using Peak detection algorithm. Technological advances in communication and low power circuit design have enabled the development of better, safer ECG devices with a capacity to incorporate the latest diagnostic features. But the issue of the sensitivity of ECG signals getting distorted by even a small noise makes the study of ECG filtering along with the various types of filters very significant. In this paper we have compare the results of ECG signal filtered by FIR filter with three windows Kaiser, Hamming and Hanning. The average power and signal to noise ratio was carried out to study the effect of noise on ECG signal.

Future work

In this paper, we proposed 'Filtering Techniques of ECG Signal Using Fir Low Pass Filter with Various Window Techniques'. In the future work we can use hamming window technique which is not used in our proposed work.

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