IRACST – International Journal of Computer Networks and Wireless Communications (IJCNWC), ISSN: 2250-3501
Vol.3, No3, June 2013

Denoising of ECG Signals with Adaptive Filters

Akanksha Deo
M.tech Student (ITM University)
Gwalior, Madhya pradeh
akanksha2689@gmail.com

DBV Singh
Associate Professor (Department of E & I Engg.)
ITM Group of Institutions, Gwalior (Madhya Pradesh)
singhdbv@gmail.com

Manoj Kumar Bandil
Associate Professor (Department of Electrical Engg.)
ITM Group of Institutions, Gwalior (Madhya Pradesh)
manojbandil@gmail.com

Dr. A K Wadhwani
Professor, (Department of Electrical Engg.)
MITS Gwalior (Madhya Pradesh)
wadhwani_arun@rediffmail.com

Abstract— ***artifact rejection has attained its clinical importance for proper diagnosis and monitoring of condition of heart. The artifacts which generally affect the ECG data are power line interference and base line wandering. In this paper, a method for removal of power line interference and base line wandering from ECG signal is proposed with help of Adaptive Filters. Conventional filters have rigid nature. They cannot change their behavior with changing conditions. Therefore , a method for denoising the ECG signal is proposed here with adaptive filtering.***

Keywords- ***ECG; power line interference; baseline wander; adaptive filters.***

I INTRODUCTION

The healthy and unhealthy condition of human organs can be verified by their electrical activity. The electrical activity of the heart is known as electrocardiography (ECG). The ECG wave has periodic nature with very slight change in its behavior. But if the changes in its behavior exceeds the predefined limits, it gives the indication of abnormal working of heart. This electrical behavior is nothing but recording of potentials emerging from heart. To record these potentials electrodes are placed according to general 12 lead systems. These electrodes are confined to the surface with the help of gel. The potential is measured between pair of these electrodes. The voltages thus recorded are very small in their magnitudes. Hence these voltages have to be amplified for analysis purpose and then recorded. The data recorded in this way from heart is referred as electrocardiogram and this process is known as electrocardiography (ECG).

The ECG has proven its importance in field of medical diagnosis of heart. The behavior of ECG changes according to each and every parametric changes occurring inside and outside patient's body. The ECG helps to detect any abnormal activity of heart which leads to trace any severe disease at its early stage.

But for accurate prediction of any abnormal functioning of heart or disease, the ECG recording must be in its pure form or free from any sort of noise. While recording the ECG, some noise is also present in raw ECG which is caused due to several reasons. This noise makes the ECG waveform contaminated. Hence for the proper diagnosis of healthy or unhealthy condition of heart, it is essential to preprocess the ECG signal. There are various mathematical tools for preprocessing of raw ECG signals which eliminates the noise from the raw ECG which increases the usefulness of the ECG data. The noise present in raw ECG data is referred as artifacts. These artifacts are present due to several reasons. Some artifacts are caused due to physiological changes inside the patient's body and some are caused due to environmental changes outside the patient's body.

The very basic technique for removals of noise is filtering. In this method, the signals are passed through high pass, low pass and notch filter. But these filters are categorized as static filters in which filter coefficients are fixed. With fixed filter coefficients, it is difficult to reduce the instrument noise because the behavior of the noise is non-stationary and unpredictable. To avoid this difficulty of static filters, various adaptive filtering methods have been adopted. In this paper various filtering methods of noise reduction have been implemented.

II ARTIFACTS IN ECG

Artifacts are undesired or unwanted interference (noise) present in desired signals. Artifacts can be caused due to the activities outside the subject or by internal activities of the subject. Various noises present in ECG are as follow:

2.1. Power Line Interference: This results from capacitance effects between 50(or 60) Hz power lines (e.g.in the walls, floor and ceiling) and the ECG recording equipment. To limit the amount of power line interference, electrodes should be applied properly, that there are no loose wires, and all components have adequate shielding. The Power line interference has frequency of 60 Hz or 50 Hz depending on the power supply anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations.

2.2. Movement artifact: This results from the movement of the subject (and hence one or more electrodes) during the ECG recording which gives rise to artifact (i.e. unwanted electrical potential changes) in the ECG signal.

2.3. Base Line Wandering: This is caused by variations in the position of the electrode with respect to the heart and changes in the propagation medium between the heart and the electrodes. This causes sudden changes in the amplitude of the ECG signal [8]. In addition, poor conductivity between the electrodes and the skin reduces the amplitude of the ECG signal and increases the probability of disturbances (by reducing SNR). The underlying mechanism resulting in these baseline disturbances is electrode-skin impedance variation. The larger the electrode-skin impedance, the smaller the relative impedance change needed to cause a major shift in the baseline of the ECG signal. If the skin impedance is extraordinarily high, it may be impossible to detect the signal features reliably in the presence of body movement [8]. Sudden changes in the skin-electrode impedance induce sharp baseline transients which decay exponentially to the baseline value.

2.4.Muscle Artifact: This results from the contraction (i.e. tremor) of skeletal muscle under an ECG electrode. Unfortunately this source of noise has a similar band width to that of the ECG and therefore cannot be removed by simple filtering techniques.[6]

2.5 Electrode Contact Noise: This results from a poor contact between an ECG electrode and the skin (e.g. due to poor adhesive or absence of conducting gel between the electrode and the skin).

2.6.Instrumentation Noise: The electrical equipments used in ECG measurements also contribute noise. The major sources of this form of noise are the electrode probes, cables, signal processor or amplifier, and the analog-to-digital converter.

Unfortunately instrumentation noise cannot be eliminated as it is inherent in electronic components, but it can be reduced through higher quality equipment and careful circuit design. Another form of noise, called flicker noise, is very important in ECG measurements, due to the low frequency content of ECG data. **[7]**

III NEED OF ARTIFACT REMOVAL

The biosignal considered in this work is ECG signal. The raw ECG gets contaminated due to various artifacts. When the doctors are examining the patient on-line and want to review the ECG of the patient in real-time, there is a good chance that the ECG signal has been contaminated by baseline wander (BW), power line interference (PLI), muscle artifacts (MA) and electrode motion artifacts (EM) etc [1], mainly caused by patient breathing, movement, power line noise, bad electrodes and improper electrode site preparation [1].The presence of these artifacts may lead to false diagnosis of functioning of heart which is not desirable.

Therefore, it is necessary to preprocess the data with the help of various mathematical tools in order to make them noise free and more informative.

The preprocessed signals thus obtained are referred as Event Related Potentials (ERP). The ERP data is very informative and very sensitive to any biological and physiological changes in human body. Hence analysis of ERP data is of very much importance in clinical use. To obtain the data in pure form is not that easy due to the presence of noise which is referred as artifacts. The artifacts can be broadly classified as internal artifacts and external artifacts. These artifacts are responsible for the contamination of raw ECG signals. Hence, it is perquisite to remove these artifacts from ECG signals to obtain suitable ERP data for efficient and reliable diagnosis. There are many methods which have been implemented for artifacts removal from ECG signals.

IV Methodology

An adaptive filter is a digital filter whose characteristics change in an unknown environment input signal. In the advanced era of cellular

phone, digital television, wireless communication and digital multimedia commercial services, advanced adaptive signal processing

may give the better solution for the technical problem. The adaptive filter is also used in the field of biomedical, sonar, radar and image signal processing, telecommunication for noise cancellation etc. Most of the applications of Adaptive Signal Processing are in telecommunication for the cancellation of noise and echoes in the transmission channel and also used in digital controller for active noise control [3]. The adaptive filters are prominent due to their economical, fast processing, their short period of time adaptation and small residual error after adaptation. [3]. An adaptive filter is a digital filter whose characteristics change in an unknown environment input signal. The adaptive filter can be defined as a filter which self adjust its transfer function according to an optimizing algorithm and object can be achieve by the modification of its characteristics [2].

The most commonly used structure in the implementation of adaptive filters is the transversal structure. In this case, the adaptive filter has a single input x(n), an output y(n) and sequence d(n) is the desired signal. The output y(n) is generated as a linear combination of the delayed samples of the input sequence x(n), according to (1),

$$y(n) = \sum_{i=0} w_i(n)x(n-i) \qquad \text{.....(3.1)}$$

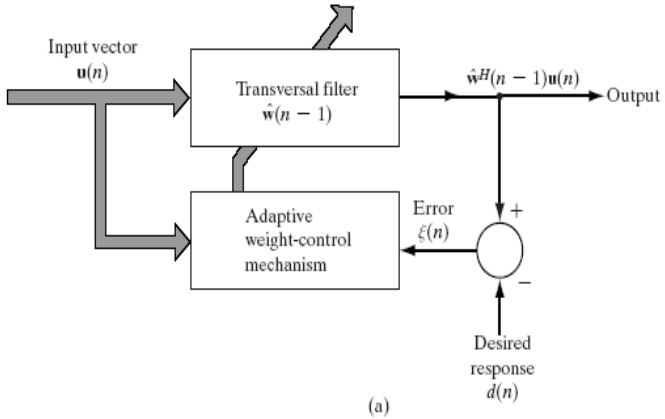

Fig 3.1: Adaptive Filtering

-A filtering process, in which an output signal is the response of a digital filter. Usually, FIR filters are used in this process because they are simple and stable.

-An adaptive process, in which the transfer function H (z) is adjusted according to an optimizing algorithm [3].

V RESULTS & ANALYSIS

To remove power line interference and base line wandering from ECG signal adaptive filtering is used in this work. For the fulfillment of the objective ECG signal is created in MATLAB environment. The created ECG signal in MATLAB environment is shown below in figure:

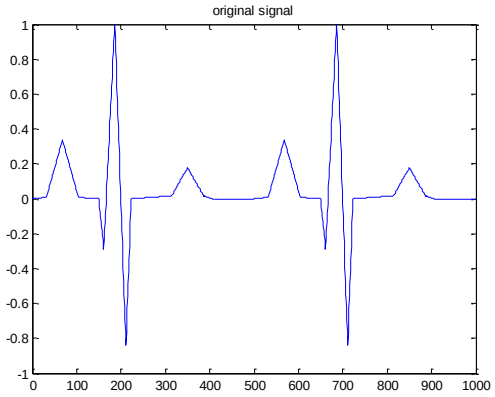

Fig4.1: ECG Waveform created in MATLAB environment

Addition of Noise to ECG Signal For testing the accuracy of denoising process of different algorithms, noise created in MATLAB environment is added to the ECG signal as shownbelow in figure 4.4, figure 4.5 and figure 4.6.

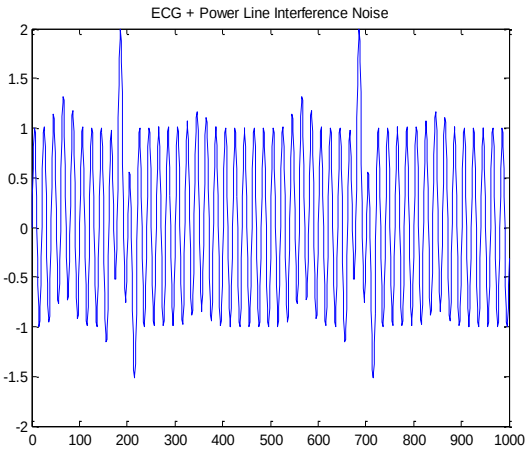

Fig 4.4: ECG + Power Line Interference

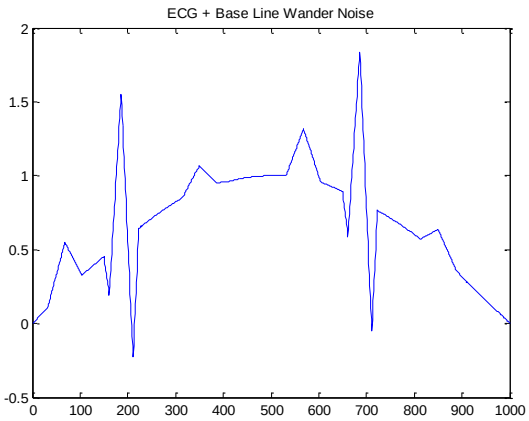

Fig 4.5: ECG + Base line wander Noise

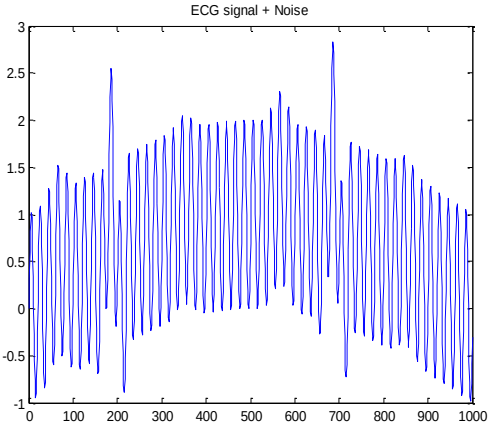

Fig 4.6: ECG + Power Line Interference + Base line wander Noise

a) Removing 50 Hz noise (Power Line Interference) from ECG signal with Adaptive Filtering:

In this method, first the ECG signal is created in MATLAB environment. The 50 Hz power line interference is also created in MATLAB environment. The ECG signal thus created is then added to the noise. This mixed signal is then denoised with an adaptive filter. The results obtained are shown as follow:

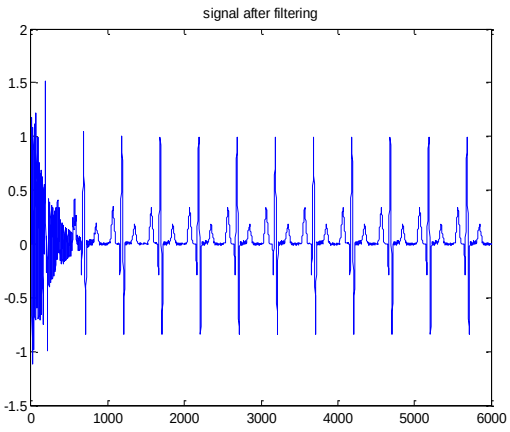

Fig 4.7: Filtered ECG from 50 Hz noise (Power Line Interference) with Adaptive Filtering.

b) Removing 0.5 Hz noise (Base Line Wandering) from ECG signal using Adaptive Filtering:

In this method, first the ECG signal is created in MATLAB environment. The 0.5 Hz base line wander noise is also created in MATLAB environment. The ECG signal thus created is then added

to the noise. This mixed signal is then denoised with an adaptive filter. The results obtained are shown as follow:

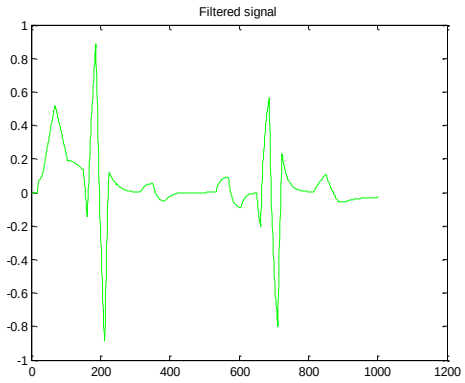

Fig 4.8: Filtered ECG Signal from 0.5 Hz noise (Base Line Wandering) with Adaptive Filtering

c) Removing 50 Hz noise (Power Line Interference) and 0.5Hz noise (Base Line Wander) from ECG signals using Adaptive Filtering:

In this method, first the ECG signal is created in MATLAB environment. The 50 Hz power line interference & 0.5 Hz base line wander noise is also created in MATLAB environment. The ECG signal thus created is then added to the noise. This mixed signal is then denoised with an adaptive filter. The results obtained are shown as follow:

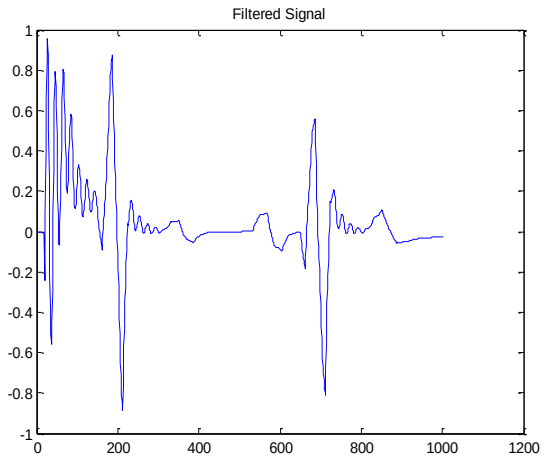

Fig 4.9: Filtered ECG Signal from 50 Hz (Power Line Interference) & 0.5 Hz noise (Base Line Wandering) with Adaptive Filtering

VI CONCLUSION & FUTURE SCOPE

In this paper, three cases are considered. The ECG signal is generated using MATLAB. The noise (Power Line Interference & Base Line Wandering) is generated using MATLAB. The contaminated ECG signal is created by adding the generated noise to generated ECG. In first case, ECG signal contaminated with power line interference of 50 Hz frequency is taken.Then this mixed signal is passed through the adaptive filter. The filtered output signal free from noise is successfully obtained. In the second case, the ECG signal contaminated with base line wander noise of frequency 0.5 Hz is taken. Then this mixed signal is passed through the adaptive filter. The filtered output signal free from noise is successfully obtained In the third case, the ECG signal contaminated with power line interference of frequency 50 Hz and base line wander noise of frequency 0.5 Hz is taken. Then this mixed signal is passed through the adaptive filter. The filtered output signal free from noise is successfully obtained. Hence it can be concluded that adaptive filter performs well in denoising the ECG signal when it is corrupted with power line interference or base line wander or both as it has fast convergence as compared to conventional static filters.

In future, methods for elimination of artifacts other than power line interference and base line wander can be developed.

REFERENCES

[1] Control and Estimation of Biological Signal (ECG) Using Adaptive System ,Sushanta Mahanty, International Journal of Electrical and Electronics Engineering (IJEEE) ISSN (PRINT): 2231 – 5284, Vol-2, Iss-1, 2012.

[2] Signal Estimation from Noisy Environment Using Adaptive Signal Processing– A LabVIEW Approach, C. V. Rambabu, JEST-M, Vol.1, Issue 2, 2012.

[3] Signal Estimation from Noisy Environment Using Adaptive Signal Processing– A LabVIEW Approach, C. V. Rambabu, JEST-M, Vol.1, Issue 2, 2012

[4] Characterization of ECG Noise Sources, Muris Mujagic, 2005.

[5]. ECG baseline wander removal andnoise suppression analysis in an embedded platform, V´ıctor Barbero Romero, Curso 2008-2009.

[6]. An automated ECG-artifact removal method for trunk muscle surface EMGrecordingsJoseph N.F. Mak1, Yong Hu∗,1, Keith D.K. Luk.Elsevir journal of Medical Enginering and Physics,2010.

[7] Ecg Artifact Removal From Surface Emg Signals By Combining Empirical Mode Decomposition And Independent Component Analysis, Joachim Taelman, Bogdan Mijovic, Sabine Van Huffel,2010.