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Review of Elimination of Power Line Interference in ECG Signal Using Adaptive Filters

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ABSTRACT: Power line interference is important in electrocardiography. Often, a proper recording environment is not sufficient to avoid this interference. The power line interference can contain higher harmonics in addition to the fundamental component. The frequency spectrum of this signal spans from near dc frequencies to about 100 Hz. In most ECG devices the sampling frequency is 240 Hz or 360 Hz. Therefore, the spectrum can theoretically include frequencies from zero to 180 Hz. Two different approaches have been proposed in literature for this purpose notch filters and adaptive interference cancellers. One of the possible alternatives to take frequency variations into account is by using an external reference power line signal. An ideal EMI filter for ECG should act as a sharp notch filter to remove only the unwanted power line interference while adapting itself automatically to variations in the frequency and level of the noise. This technique is available by using adaptive filters only and there are serious practical difficulties to implement

KEYWORDS: ECG signal, Power line interference, Removal of noise, Adaptive interference canceller.

I. INTRODUCTION

An ECG signal is the electrical recording of the functionality of the heart. ECG gives the record of the waveforms that shows the electrical activity of the heart. Power line interference may be significant in the ECG. Power line interference coupled to cables that carry the signal causes trouble in medical equipments such as ECG. ECG signals are distorted severely by the noise present in the power line, therefore sharp notch filter is necessary to separate and remove the noise. The interference commonly resembles an additive type of signal. Therefore the measured corrupted signal is the sum of desired signal and the interference. An ideal power line suppression method should eliminate interference in power line without harming the signal of interest. Power line interference coupled to signal carrying cables is troublesome particularly in the medical equipment such as electrocardiograms. The cables carrying ECG signals from the examination room to the equipment used for monitoring are susceptible to electromagnetic interference of power frequency (50 Hz or 60 Hz) by supply lines and plugs noise. Filtering such EMI signal is a challenging problem since the frequency of the power line signal which is time- varying lies within the frequency range of the ECG signal. There are some other technical difficulties involved such as the low sampling frequency at which the ECG signals are taken and the low computational resources available at the apparatus level. The interference is commonly taken as an additive signal. Thus, the measured corrupted signal is the addition of the desired signal and the interference. An ideal power line interference suppression method should remove the power line interference while preserving the signal of interest. For this reason, two different types of approaches which can be used are notch filters and adaptive interference cancellers. Notch filters reduce the power line interference by suppressing the predetermined frequencies. Normally an infinite impulse response or IIR filter is adopted. The phase spectrum and the magnitude of the ECG signal are less affected by narrow suppression band filters. Hence, the suppression band of the notch filter should be very narrow. However, this leads to difficulty whenever the frequency of power line is unstable or not accurately known. Thus, a mismatch between the power line frequency and suppression band might lead to inadequate reduction of the power line interference.

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II. LITERATURE REVIEW

The paper gives an improved adaptive canceller for the reduction of the fundamental power line interference component and harmonics in electrocardiogram (ECG) recordings. The method tracks the amplitude, phase, and frequency of all the interference components for power line frequency deviations up to about 4 Hz. A comparison is made between the performance of our method, former adaptive cancellers, and a narrow and a wide notch filter in suppressing the fundamental power line interference component. For this purpose a real ECG signal is corrupted by an artificial power line interference signal. The cleaned signal after applying all methods is compared with the original ECG signal. Our improved adaptive canceller shows a signal-to-power-line-interference ratio for the fundamental component up to 30 dB higher than that produced by the other methods [1].

This paper represents, an existing adaptive interference canceller which is modified by considering the error at the neighbouring samples to estimate the power line interference parameters. The performance of the modified adaptive canceller is further improved by using error filtering. The adaptive interference canceller has been modified by replacing the squared-error at each sample by mean-square-error of an error vector in the LMS algorithm [2].

This paper proposed Kalman based least mean square (KLMS) filter. The Kalman based Least mean square filter removes the 50Hz interference in power line and essentially minimise the mean square error. As per the experimental results, the Kalman based LMS filter is better as compared to other filter techniques. Using MATLAB the 4-beat original ECG signal is generated whose amplitude is 1mv and sampling frequency is 500 Hz for each beat. The 50 Hz power line interference is also produced with sampling frequency of 2000 Hz. Now to get the mixed signal, PLI is then added to the original ECG signal. Finally, using different adaptive filters based on different algorithms such as DLMS, BLMS, XLMS and Kalman based LMS algorithm, the power line interference is removed [3].

This paper includes two types of adaptive filters which are considered to reduce the ECG signal noises like Base Line and power line Interference. Results of simulations are presented in MATLAB. The results s
of simulation show that LMS algorithm give good results as compared to RLS algorithm in the area of Biomedical Signal Processing for noise cancellation. For completing the task of noise reduction, LMS filtering results is relatively good and the requirements length of filter is relatively short. It also have simplified structure as well as small operation and is easy to realize hardware. But the shortcomings of LMS algorithm is due to the slow convergence rate. The signal power and noise signal when compared to larger, LMS filter output is unsatisfactory, but we can still step through the adjustment factor and the length of the filter method for improvement [4].

This paper gives information about an Adaptive filtering method that can realize effective extraction of non-stationary signals without having any prior knowledge about signal and noise. In this paper, adaptive noise cancellation system for power interference suppression and ECG signal base line filtering given as well as construct an iterative time LMS algorithm combining the fixed and variable step size that effectively solves the problems of filtering the SNR and convergence rate. The results of experiment show that this method eliminates base line drift and power interference effectively as well as improves 26.36dB in SNR. It extracts ECG signal accurately and converges quickly. It has important practical value in medical clinical diagnosis [5].

III. ECG SIGNAL

An ECG signal is an index of the electrical activity of the heart. A physician can detect arrhythmia by studying abnormalities shown in the ECG signal. Since very fine characteristics present in an ECG signal carries important information, so it is necessary to have the signal as clean as possible. The frequency spectrum spans from near dc frequencies to about 100 Hz for this signal. The sampling frequency is 240 Hz or 360 Hz in most ECG devices. Hence, the spectrum can theoretically include frequencies ranging from zero to 180 Hz. ECG signals are severely distorted by the noise present in the power line. Therefore sharp notch filter is essential to separate and remove the noise. The notch filter is ineffective because frequency of power line is not stable and varies about fractions of a Hertz, or maybe a few Hertz. The sharper the notch filter is made, the more inoperative it becomes if any change in the frequency of the power line occurs. This turns the notch filter into a band-stop filter by widening its rejection band, thereby accommodating

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frequency variations, but does not provide any better solution since it will undesirably distort the ECG signal itself. When conventional EMI filters are designed for ECGs, the power grid frequency is usually taken as being constant. In such type of arrangements, the system is very sensitive with respect to the power frequency variations and thus can become totally inactive or inoperative.

One possible alternative to take frequency variations into account is by the use of an external reference power line signal. An ideal EMI filter for ECG should act as a sharp notch filter to remove only the unwanted power line interference while adapting itself automatically to the level of noise and the frequency variations. This technique is available by using adaptive filters only and there are serious practical difficulties to implement. For this reason, other methods, usually very complicated and inflexible, are being proposed constantly. An ideal EMI filter for ECG should act as a sharp notch filter to remove only the undesirable power line interference while adapting itself automatically to variations in the frequency and level of the noise. This adaptation must be done very quickly so that the signal is kept clean all the time. It is supposed to be able to work in low information background, especially dictated by low sampling frequency. It must be robust with respect to variations in its external as well as internal conditions. An example of internal condition is its settings whereas the external conditions can range from the temperature of the environment in which the equipment is supposed to function to the superimposed noise/distortion on the interfering power signal.

IV. ADAPTIVE CANCELLER

The interference is commonly a type of an additive signal. Therefore, the measured corrupted signal is the sum of the desired signal and the interference. An ideal power line interference suppression method should eliminate the power line interference without destructing signal of interest. Therefore, notch filters and adaptive interference cancellers are two different type approaches which can be used. Notch filters reduce the power line interference by suppressing the frequencies that are predetermined. Usually, an infinite impulse response or (IIR) filter is adopted. The magnitude and phase spectrum of the ECG signal are less susceptible to narrow suppression band filters. Therefore, the suppression band of the notch filter should be very narrow. However, this leads to many problems whenever the power line frequency is not accurately known or is unstable. A mismatch between the power line frequency and the suppression band might lead to inadequate power line interference reduction.

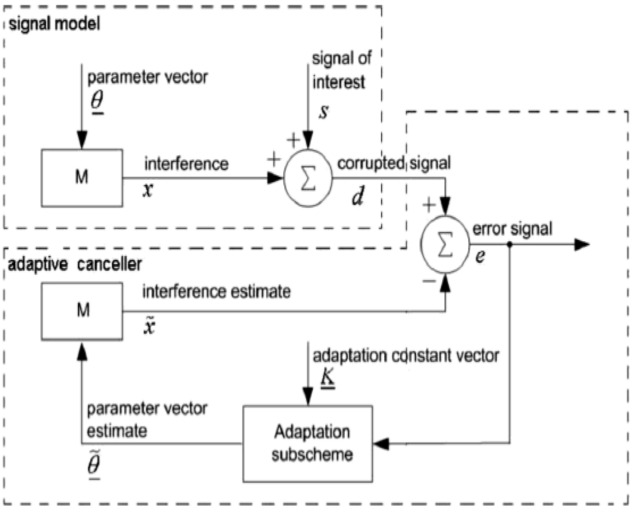

Figure 1 General Structure of Adaptive Interference Canceller

The above figure shows the general structure of Adaptive interference cancellers. It consist of the interference signal, the signal of interest or desired signal, and the corrupted signal. The representation of interference may be as a known function of the interference parameter vector. The input signal if sinusoid, for instance, the interference parameter vector may contain its phase and amplitude. An interference estimate is internally generated as a function of the estimated parameter vector. The difference between the corrupted signal and the estimated interference is the error

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signal. This is processed by an adaptation sub-scheme in order to roughly calculate the value of frequency. The sub-scheme behaviour is dependent on the adaptation constant vector. It is common to assume and to be uncorrelated and configure the adaptation sub-scheme in such a way that the mean-squared error or (MSE) is minimized. This is referred to as least mean square (LMS) estimation. Now after convergence, the error is a value or an estimate for the signal of interest or desired signal which is the ECG signal.

V. METHODOLOGY

To implement notch filter and estimate its performance for removal of power line interference. Now implementing and estimating the performance of adaptive canceller using LMS algorithm for removal of power line interference. Device the method for improvement and then compare the results of given method with the other methods.

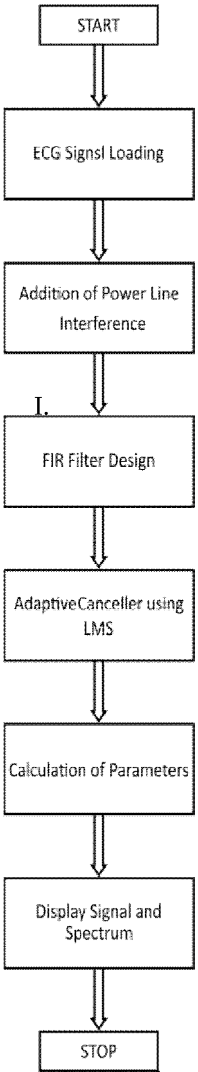

Figure 2. Flowchart shows the procedure for the power line interference removal

VI. SUMMARY

Power line interference is a challenging problem given that the frequency of the time-varying power line signal lies within the frequency range of the ECG signal. Some technical difficulties involved are low sampling

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frequency at which the ECG signals are obtained and the low computational resources available at the level of the apparatus. The use of adaptive notch filter is one of the possible alternatives to take frequency variations into account. An algorithm called as the Least mean-square algorithm is used on adaptive filtering. Therefore, a devise method for adaptive notch filter to remove the power line interference in ECG signal can be utilised in the medical equipment's to eliminate the noise caused due to AC supply.

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