INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

REMOVAL OF POWER LINE INTERFERENCE FROM ECG SIGNAL USING ADAPTIVE FILTER

MS.VRUDDHI LAXMIDAS DAWDA[1], PROF. MOHD. SALEEM. SAJID[2]

1. Second Year M.E (Digital Electronics), DBNCOET Yavatmal, SGBAU Amravati, Yavatmal, India.
2. Assistant Professor (EXTC Dept), DBNCOET Yavatmal, SGBAU Amravati, Yavatmal, India

Accepted Date: 05/03/2015; Published Date: 01/05/2015

Abstract: Electrocardiogram (ECG) is extremely important in the diagnosis of patient's heart condition which is commonly recorded with a noise. Many different kinds of noise exist in biomedical environment such as Power Line Interference (PLI), baseline wander and noise due to muscles contraction and relaxation. Out of them, PLI is main source of noise which badly affects the characteristics of ECG signals. Removal of power line interference is an important task for analyzing ECG signal. There are two types of PLI that are stationary and non-stationary. Notch filters are used to remove stationary power line interference and adaptive cancellers are used to handle non-stationary power line interference. The adaptive filter can adjusts the filter coefficients according to the adaptive algorithm. In this paper, an effective adaptive algorithm can be used for eliminating 50Hz (or 60Hz) power line interference from ECG signal. Matlab is used to design the filter algorithm and tested on ECG signal corrupted with various power line frequencies. The proposed method can also be used to filter out the PLI from ECG which having low signal-to-noise ratio (SNR).

Keywords: Electrocardiogram (ECG), Adaptive Filter Techniques, Adaptive Algorithm, Power Line Interference, Signal to Noise Ratio, Percentage Mean Square Error.

Corresponding Author: MS.VRUDDHI LAXMIDAS DAWDA

PAPER-QR CODE

Access Online On:

www.ijpret.com

How to Cite This Article:

Vruddhi Laxmidas Dawda, IJPRET, 2015; Volume 3 (9): 479-486

INTRODUCTION

ECG signal plays a vital role in biomedical field. But ECG signal will be mixed with the power-line interference. The research on the PLI removal is the hot topic of the biomedical area. ECG signal with the power line interference, will cause an impact on analysis of heart condition of the patients, so it is very important to remove power-line interference effectively in ECG signal processing. The power-line interference can be assumed to be a sinusoidal wave. But practically, power-line interference signal is non-stationary. So we proposed an effective adaptive algorithm for removing power-line interference. In this paper, we can remove the interference component from the input ECG signal to estimate power-line interference. For a high quality analysis of the electrocardiogram (ECG), the amplitude of the power line interference should be less than 0.5% of the peak-to-peak QRS amplitude [1].Before doing any further analysis the PLI should be removed from ECG signal by using ideal PLI suppression method, while keeping the ECG signal as it is.

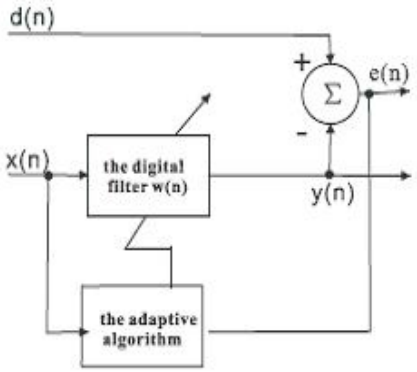

Figure 1. General adaptive filtering diagram.

Above given figure is general adaptive filtering technique, the digital filter w (n) is applied on input side x(n), which produce an output signal y(n). Adaptive algorithm adjusts the filter coefficient which included vector w(n) in order to minimize the error signal e(n).Error signal is nothing but difference between the desired signal d(n) and output signal y(n).

- **RELATED WORK**

Power line interference (PLI) is the noise that commonly disturbs the basic electrocardiogram signal (ECG).Many researchers have been made contributions regarding noise removal of ECG signal. Here we review on research work done by various authors.

Using an external reference signal, power line interference from ECG signal is eliminated by adaptive filtering was first proposed by Widrow [6].In this paper main advantage is to reduce periodic or stationary random interference in both periodic and random signals. But the disadvantage is, it requires external reference signal with each instant of PLI cancelling which was accomplished with little signal distortion. Ahlstrom and Tompkins [7] reported on an adaptive 60-HZ filter for ECG signals that used an internally generated reference signal. Also Ahlstrom and Tompkins' adaptive filter is less complex, produces less distortion in a typical ECG, and it is effective work in removing low level 60-Hz noise. But Ahlstrom and Tompkins' filter is nearly similar to a nonadaptive, second order, notch filter, implying that the performance of a nonadaptive notch filter and an adaptive notch filter with an internally generated reference is equivalent. If there is small difference occurs in bandwidth then the transient response time of notch filter is also affected and hence the filter will adapt more slowly to changes in noise [7].

Neural network based nonlinear adaptive filter [8] has a better way to eliminate the baseline drift, pseudo-differential effects. But the adaptive filter used in the template, which are subject to the impact of variation of QRS wave, while the neural network with large amount of arithmetic operations, is big limitation for the clinical application for analysis of ECG.

Adaptive canceller based on first order phase adaptation system was proposed by A. Ziarani and A. Konrad [9]. Method presents in this paper having simple and robust structure. This paper represents structure and performance of the proposed nonlinear adaptive EMI filter and its application in the elimination of power line interference in ECG signals. The structure of nonlinear adaptive EMI filter consisting of only few arithmetic operations and it has a high degree of immunity with respect to an external noise.

The drawbacks of adaptive canceller in [9] have been improved in [4]. It is achieved by replacing the first order phase adaptation system by a second order phase-locked loop (PLL) system. S. Marten [4] compare their improved adaptive power line interference canceller (IAC) to the canceller proposed by Ziarani [9] for the reduction of the fundamental power line interference component in ECG recordings. The results show that the value of the adaptation constant vector proposed by Ziarani for the canceller in [9] does not always lead to a successful acquisition phase. In fact, the canceller design is such that the optimal adaptation constant vector is dependent on d(k). Where d(k) is interference signal [4]. The adaptive canceller tracks the amplitude, phase and frequency of the fundamental component and harmonics of the power line interference [4]. The error filter that is implemented in the canceller can reduce the gradient noise cause by the ECG signal and baseline wander [4]. For removing power line interference from ECG signals based on EMD and adaptive filter was proposed in [10], [12]. The

performance of the method was tested with actual ECG signals. EMD was developed as a non-parametric data-driven analysis tool for nonlinear and non-stationary signal processing. It exhibits an ability to analyze signal with excellent time resolution. Most widely used adaptive filtering algorithm is Least Mean Square (LMS) algorithm developed by Window and Hoff which is simple and powerful. Results indicate that without affecting ECG signal spectrum power line interference can be eliminated from ECG signal [10], [12].

A novel algorithm was proposed for power line interference (PLI) detection and suppression also to pre-process real time electrocardiogram (ECG) signals based on recursive least square (RLS) adaptive notch filter instead of LMS [11],[12].The proposed algorithm first compares the energy at the harmonic frequency against the energy at neighboring frequencies of the ECG power spectrum, and employs an optimal linear discriminant analysis (LDA) algorithm to determine whether PLI interference exists in the ECG signal. If the presence of PLI is detected, it then applies a recursive least square (RLS) adaptive notch filter to suppress the interference. Extensive simulation results indicate that the algorithm consistently exhibits superior performance in terms of less ECG distortion, faster convergence rate and numerical stability [11], [12].

In [6] H. N. Bharath and K. M. M Prabhu proposed error filtering and adaptive blocking methods. In this paper the performance of the windowed adaptive canceller (WAC) in suppressing PLI is compared with the IIR notch filter, the normal adaptive power line canceller (APC) and the improved adaptive canceller (IAC) proposed in [4]. By using error filtering and adaptation blocking method the performance of modified adaptive canceller is improved [5]. The windowed adaptive canceller (WAC) proposed in this paper [5] gives the best performance while dealing with randomly varying frequency deviations. When the frequency deviation is constant, the performance of windowed adaptive canceller (WAC) is poorer, when compared to the improved adaptive canceller (IAC). However, the proposed modified windowed adaptive canceller (WMAC) performs better than the improved adaptive canceller (IAC). However, the performance of improved adaptive canceller (IAC) without adaptation blocking is very poor compared to the windowed adaptive canceller (WAC) or the modified windowed adaptive canceller (MWAC) [5].

- **PROPOSED WORK**

Our proposed work is focusing mainly on to improve the signal to noise ratio (SNR) and another factor to be improved is correlation coefficient which gives us the similarity between filtered and non-filtered signal. The processes involved in this study are as follows:

1. To make the comparative analysis of different available methods of adaptive power line interference removal from literature.
2. To choose the different significant parameters which can analyze the performance of the algorithm.
3. To find a new method for removal of adaptive power line interference from biomedical signal.
4. To write the algorithm for proposed method using software like Matlab.
5. To make an analysis for the performance of implemented algorithm based on the significant parameters.
6. To compare performance of implemented algorithm with available method in the literature.

Algorithm

Define the of k,ϕS, ϕI

```
vS=exp(1j*(i1)*2*pi*d*sin(øS));

vI=exp(1j*(i-1)*2*pi*d*sin(øI));

I=rand(N.k) %interference signal

for n = 1:k)

x = S(n)*vS + I(n)*vI/kalman equations;

%y = w*x.';

y=w'*x; %output signal

e = conj(S(n)) - y; %error signal

w=w+mu*conj(e)*x; %weights update

end

End
```

Arrayfactor=w* e-j(k) πsinϕ

The equation for kalman filter is given by p(n+1)+qv/σ(n+1).Moreover, a pragmatic step size (μ) is used for algorithm updating and determining both how quickly the adaptive filter adapts to the filter solution. This algorithm uses a steepest decent method [4] and computes the weight vector recursively using the equation.

Then the reconstructed signal's signal-to-noise ratio (SNR), percentage mean square error (%MSE) and error standard deviation (ESD) are calculated to measure the performance of different adaptive filters.

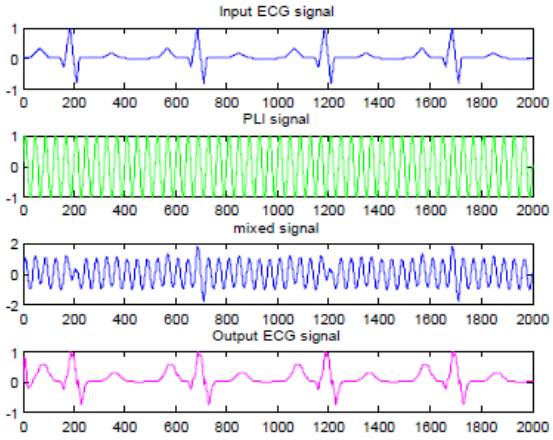

Figure 2: Power Line Interference removal using adaptive filter

- **CONCLUSION**

In this paper, the review of research work done by various authors is discussed. Also we propose adaptive filter technique which is able to remove the power line interference from ECG signal. The adaptive filters can adjust the filter coefficients according to the adaptive algorithm. By adjusting the filter coefficient the power line interference from ECG signal is completely removed. It should give the better SNR and Correlation coefficient nearer to 1.

REFERENCES

1. M. Sushmitha, T. Balaji, "Removing the Power Line Interference from ECG signals using Adaptive Filters," IJCSNS International Journal of Computer Science and Network Security, VOL.14 No.11, November 2014 pp 76-80

2. C. Van Rijn, A. Pepar, and C. A. Grimbergen, "High Quality Recording of Bioelectric Events.Part1.Interference Reduction, Theory and Practice," Med. Biol. Eng. Comput, vol. 28, no.5, pp.389-397, 1990.

3. Chin-Chia Chang, Bor-Shyh Lin, Jen-Chien Chien, Yue-Der Lin, and Fok-Ching Chong, "A Feature Enhancement Adaptive Structure For Removing Residual Power-line Interference", 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2001.

4. Bor-Shyh Lin, Nor-Shing Lin, Wan-Chi Lee, Fok-Ching Chong, and Yue-Der Lin, "Removing Residual Power-Line Interference using WHT Adaptive Filter", 24rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2002

5. S.Martens, M.Mischi, S.Oei and J.Bergmans, "An Improved Adaptive Power Line Interference Canceller for Electrocardiography," Biomedical Engineering, IEEE Transactions on, vol. 53, no. 11, pp. 2220-2231, nov.2006.

6. H. N. Bharath and K. M. M Prabhu, "A New LMS Based Adaptive Interference Canceller for ECG Power Line Removal," in International Conference on Biomedical Engineering, 2012

7. B. Widrow, et al "Adaptive Noise Cancelling: Principal and Application," Proceeding of IEEE, vol.63 pp. 1692-1716, 1975

8. M. L. Ahlstrom and W. J. Tompkins, "Digital filter for real time ECG signal processing using microprocessors," IEEE Transactions on Biomedical Engineering, vol. BME- 32 pp. 708-713, 1985.

9. Q. Xue, Y. Hu, et al, "Neural-network base adaptive matched filtering for QRS detection", IEEE Transactions on Biomedical Engineering, vol. 39, pp.317-329, 1992.

10. Alireza K. Ziarani and Adalbert Konrad, "A Nonlinear Adaptive Method of Elimination of Power Line Interference in ECG Signals," Biomedical Engineering, IEEE Transactions on, vol.49, no.6,pp. 540-547, june.2002.

11. Zhao Zhidong, et al, "A Novel Cancellation Method of Power Line Interference in ECG Signal Based on EMD and Adaptive Filter," in 11th IEEE International Conference on Communication Technology, 2008.

12. Y H Hu, et al, "Detection and suppression of power line interference in electrocardiogram signal," in Journal of Computer in Cardiology, vol. 34, 2007, pp.549-552.

13. Abhay R. Kasetwar and Sanjay M. Gulhane, “Adaptive Power Line Interference Canceller: A Survey,” International Journal of Advances in Engineering & Technology, Jan. 2013.

14. V. J. Mathews, “Performance analysis of adaptive filters equipped with the dual sign algorithm, “IEEE Transaction on Acoustics, Speech and Signal Processing, vol. 39,pp. 85-91,1991