Adaptive Interference Canceller for ECG Signal Processing

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Abstract

Manystudies have been devoted to the adaptive power-line interference (PLI) canceller design for ECG signal processing. However, almost all existing PLI canceller are developed for applications in which the presence of PLI is assumed a priori. The implementation of adaptable PLI canceller using Least Mean Square (LMS) algorithm to remove the power-line interference (50/60 Hz) from electrocardiogram (ECG) is proposed in this article. The adaptable PLI canceller adjusts its parameters automatically to remove the PLI. Experimental results demonstrate performance of these proposed algorithms.

Keywords: *PLI, LMS algorithm, Electrocardiogram*

I. INTRODUCTION

One of the application areas of signal processing techniques is biomedical engineering such as electrocardiography. An ECC signal is index of functionality of heart which has very important role in the diagnosis of heart diseases. Very fine features of ECG signal convey important information, it is important that ECG signal must be noise free.

Most of the medical equipments used in hospitals are powered by power supply of working frequency 50/60 Hz. American Heart Association recommends that ECG signal recorder have 3dB frequency range from 0.67Hz to 150Hz. As power supply frequency lies within the frequency range of ECG signal, measured ECG signal is corrupted by power line interference (PLI) [2].PLI with low frequency and weak amplitude may totally mask the signal of interest and affects the reliability and accuracy of ECG signal. For the quality analysis of cardiac diseases PLI should be removed from ECG signal, while keeping ECG signal intact [4].

Traditional approach to remove PLI is notch filter with narrow rejection bandwidth. This approach is not suitable when PLI is non-stationary in nature, so adaptive interference canceller is required.

The purpose of an adaptive interference canceller is to subtract non-stationary type of noise from a received signal in adaptively controlledmanner so as to improve the signal to noise ratio [Haykin]

In adaptive PLI cancellation method, PLI is calculated by minimizing difference using different typesof algorithms. This calculated PLI is subtracted from ECG signal to cancel the PLI at every successive iteration [7].

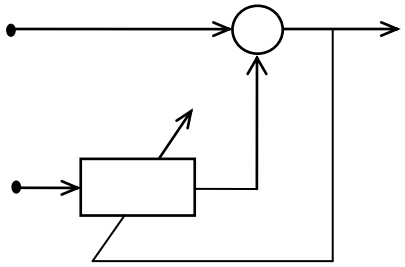

Fig.1 Adaptive Interference Canceller

The adaptive interference canceller shown in fig.1 operates on the reference PLI input i(n) to produce estimate of the noise which is then subtracted from the desired signal d(n).

If we assumed input data to be real valued, pure ECG signal s(n) and PLI i(n) are uncorrelated then desired signal

$$d(n) = s(n) + i(n) \quad \text{.....(1)}$$

Weight Update by means of LMS

$$w(n+1) = w(n).2.\mu.i(n).e(n) \text{.....(2)}$$

Where

μ is the step size parameter and e(n) is error signal which is given by

$$e(n)=d(n)-y(n) \text{ .....(3)}$$

II. LITERATURE REVIEW

Researchers from the field a bioengineering continue now a days to improve or to find new solution for practical implementation of processing algorithms, regarding the ECG signal PLI caused by power supply network are not stable overtime due to frequency variation of sinusoidal wave form of voltage. An adaptive filter is the best solution for removal of PLI from the biomedical signal [9].

The first used adaptive method to remove 50/60 Hz interference from a corrupted ECG signal using adaptive filter was propose by Widrow in 1975[8]. This method is very robust and has the capability to remove 50/60 Hz interference [8]. The problem in the recording of ECG is the appearance of unwanted 50Hz PLI in the measurement signal because of magnetic induction, displacement and equipment interconnection, so for suppress this noise an author propose diverse techniques for minimizing it by proper grounding and twisted pair. An implementation of an adaptable suppresser of the signal interference using FPGA [10]. There are diverse techniques for minimizing appearance of unwanted interference such as proper grounding and use for twisted pair,signal averaging which enhance the signal with random noise, impedance matching analysis, ECG noise filtering using wavelets. These method do not ensure optimum performance, for the removal of PLI the Author implemental an adaptive noise canceller on FPGA. And adaptive canceller exhibits the better performance than the traditional solution

Mohammed Bahoura et. Al. implement a sequential architecture of a pipeline LMS based adaptive noise canceller to remove PLI from the ECG signal is implemented on FPGA using Xilinx system generator. For implementing filter several different architecture like sequential, parallel and semi-parallel, for selection of any architecture to most important factor are sample rate and numberof coefficient [11].The FPGA implementation of an adaptive linear neural network (ADALINE) based on PLI cancellation in surface electromyography (sEMG) was proposed by N.Jindapeth and S. Chewae in 2011 , In previous work there is a need of external of reference signal to system but as they are used ADALINE adaptive fiter, There is no need for the external reference signal in system because the delay version of measurable signal is consider as a reference.[13]. The authors in [12]describe a method which compute adaptive filter structure and real time implemented on FPGA . The LMS algorithm is used to update update up to twelve coefficient from the filter structure.

Increase in the attenuation level of notch filter PLI noise will remove effectively however increase bandwidth disturbs the nearby spectrum. This is the major drawback of using notch filter for removal of PLI from ECG signal [2].

Ziarani et al proposed nonlinear adaptive EMI filter for removal of PLI from ECG signal. Structure of EMI filter is highly simple and required only few arithmetic [5].

Adaptive noise canceller (ANC) method with internal reference signal is introduced by Ziarani which is more complex structure. Martents et al (2004) proposed simple adaptive noise canceller as improvement in Widrow (1975) method and neglecting the presence of PLI harmonics [6].

Ziarani proposed very practical method for PLI removal but adaptation constant may not lead to a successful equation phase. The improved adaptive canceller (IAC)is proposed by Martens et al (2006) with important improvement such as phase adaption replaced by PLL [7].

Scheer and Ider proposed a technique for adaptation blocking based on QRS complex detection.

Yue-Der Lin and Yu Hen Hu proposed LDA based adaptive filter overcome drawback of unrealistic ass umptions for existing methods with less computational complexity.Structure is capable to eliminate PLI with variable frequency and other sinusoidal interference [3].

III. METHODOLOGY

A block diagram of the proposed adaptive PLI canceller technique is depicted in figure 1. This proposed adaptive canceller is capable to suppress the PLI in ECG recordings. Clean ECG signal recorded at Beth Israel Hospital (BIH) in Boston and made available by Massachusetts Institute of Technology (MIT) is taken for simulation. This clean ECG signal polluted by synthetically generated PLI having 50Hz frequency. The same PLI is provided to adaptive filter as a reference signal. Weights of filter are automatically update using LMS algorithm in recursive manner. Adaptation blocking is used hand in hand to improve the performance of the filter. Adaptation blocking method finds the large amplitude QRS section of ECG wave. For that section estimation is not performed, instead of that previous estimated parameters are used to remove PLI. Choosing step size parameter again a critical task. Larger value of step size parameter can increase the speed of convergence but affect the stability of system and smaller value gives better stability but decrease speed of convergence.

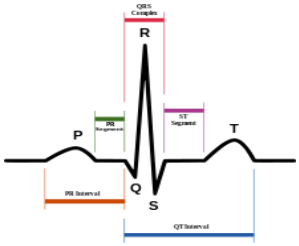

Fig.2ECG wave

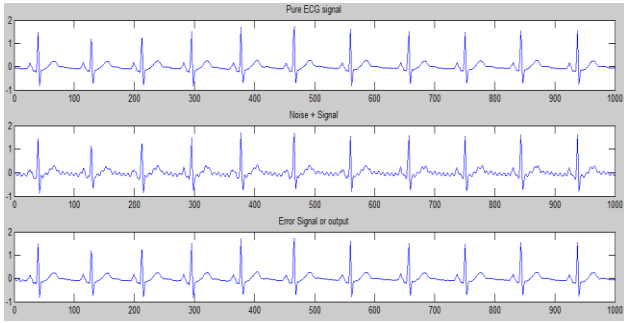

Fig.3Results of Adaptive Interference Canceller

IV. CONCLUSIONS

Cancellation of Power Line Interference from ECG signal is a challenging problem as frequency of Power Line Interference may change with time. Our simulation in figure 2 shows the performance of the adaptive inference canceller. Blocking the parameter estimation during large amplitude section will improve the performance of system. The proposed adaptive filter is simple which requires low level of computational resources.

REFERENCES

[1] Rafel Ramos, Antoni Manuel-Lazaro, Del Rio "FPGA-based Implementation of an adaptive canceller for 50/60 Hz interference in Electrocardiography" *IEEE Transactions on* Instrumentation and Measurement, Vol. 56, No. 6, December 2007.

[2] Maryam Butt, Nauman Razzaq, Ismail Sadiq, "Power Line Interference removal from ECG Signal using SSRLS Algorithm" 9th International Colloquium on Signal Processing and Applications, 2013.

[3] Yue-Der Lin, Yu Hen Hu "Power Line Interference Detection and Suppression in ECG Signal Processing," IEEE Transactions on Biomedical Engineering, Vol.55, No.1 January2008.

[4] H. N. Bharat, K. M. M. Prabhu, "A New LMS based Adaptive Interference Canceller for ECG Power Line Removal," International Conference on Biomedical Engineering February, 2012.

[5] Alireza K. Ziarani, Adalbert Konrad "A Nonlinear Adaptive Method of Elimination of Power Line Interference in ECG Signals,"IEEE Transactions on Biomedical Engineering, Vol.49, No.6 June 2002.

[6] Martens S.M.M., Bergmans J.W.M. and Oei S.G..,(2004) " A Simple adaptive interference cancellation method for power line reduction in electrocardiography", proceeding of 25th Symposium on Information Theory in the Benelux, pp. 49-56.

[7] Martens S.M.M., Mischi M.,Oei S.G, and Bergmans J.W.M. (2006) " An improved adaptive power line interference canceller for electrocardiography", IEEE Transactions on Biomedical Engineering, Vol.53, pp. 2220-2231.

[8] B. Widrow et al '"Adaptive noise cancelling : principles and application." proceeding of the IEEE , Vol.63,no.12.pp.1692- 1716.dec.1975.

[9] Ioan Tudosa , Narcis adochiei , "FPGA Approch of an Adaptive filter for ECG Signal processing" EPE-2012.PP. 25-27

[10] R. Romas , A. Manuel et al "Application by means of FPGA of an adaptive canceller 50 Hz interference in electro-cardiographyIEEE Instrumentation and Measurement Technology.2001

[11] Mohammed Bahoura , Hassan Ezzaidi , "FPGA-Implementation of a sequential Adaptive Noise Canceller using Xilinx SystemGenerator" 2009 International conference on Microelectronics

[12] S. Banerjee and A .Sinha , "Performance analysis of different DSPalgorithms on advanced microcontroller and FPGA". Proc .OfACTEA, pp.6009-613,15 -17 july 2009

[13] N. Jindapetch et al "FPGA implementation of an ADALINE filter for power –line noise cancellation in surface electromyography signals"2011 ELSEVIER.