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Review on Design & Realization of Adaptive Noise Canceller on Digital Signal Processor

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ABSTRACT

One of the main problems in biomedical data processing like electrocardiography is the separation of the wanted signal from the noises caused by power line interference, external electromagnetic fields, random body movements and respiration. Different types of digital filter are used to remove signal components from unwanted frequency ranges. It is difficult to apply filter with fixed coefficient to reduce the biomedical signal noises, because human behaviour is not exact known depending on the time. Adaptive filter technique is required to overcome this problem. An Adaptive noise canceller based on an improved algorithm has been designed by DSP. The algorithm is introduced and simulated in MATLAB, then realized on the digital signal processor.

Keywords: Adaptive noise canceller (ANC), DSP, LMS, NLMS, Power line interference (PLI), MATLAB

I. INTRODUCTION

Noise problems in the environment have gained attention due to the tremendous growth of technology that has led to noisy engines, heavy machinery, high electromagnetic radiation devices and other noise sources. The problem of controlling the noise level has become the focus of a vast amount of research over the years. Bernard Widrow developed a model for noise cancelation with the help of adaptive filter and employed for variety of practical applications like the cancelling of various forms of periodic interference in electrocardiography, the cancelling of periodic interference in speech signals, and the cancelling of broad-band interference in the side-lobes of an antenna array. Power line interference coupled to signal carrying cables is particularly troublesome in medical equipment such as electrocardiograms (ECGs). Cables carrying ECG signals from the examination room to the monitoring equipment are susceptible to interference of power frequency (50 Hz or 60 Hz) by ubiquitous supply lines and plugs noise that sometimes the ECG signal is totally masked. Filtering such interference signal is a challenging problem given that the frequency of the time-varying power line signal lies within the frequency range of the ECG signal. There are some other technical difficulties involved, the most important of which is the low sampling frequency at which the ECG signals are taken and the low computational resources available at the level of the device. In the most of practical applications Adaptive filters are used and preferred over fixed digital filters because adaptive filters have the property of self-modifying its frequency response and allowing the filter to adapt the response as the input signal characteristics change.

I. LITERATURE SURVEY

This section describe a various techniques proposed by different researchers.

In this paper, an effective adaptive filter structure is proposed to minimize the residual power-line

interference without loss of reality. In order to obtain a satisfactory and acceptable convergence performance, Walsh Hadamard Transform (WHT) is used in the adaptive filter. The backbone is an adaptive cancel filter. The corrupted ECG is the primary input. From this, the component that is correlated with noise is the reference input. To obtain this correlated signal, the signal is processed by FFT and extracted the significant interference bandwidth spectrum. Then IFFT is performed to recover the interference signal and used as the reference input. After transformation the eigen values are group into M-point outputs and adaptively processed by M stages of sub-band adaptive filters using NLMS algorithm. Throughout many clinical measurements, the result of this structure is effective in eliminating EMI interference [1].

The method proposed in this paper is non–stationary tracking approach for the power line interference by means of Kalman filtering that allows improved discrimination between the ECG signal and the noise. This method properly reduces this interference during its stationary segments and keeps its high performance during amplitude and frequency variations. One of the main shortcomings of the Kalman filter methods, the parameter setting, was proposed to be solved with the implementation of a genetic algorithm obtaining a set of parameters, being optimal in the correlation index sense. The search surface shows that the EKF power line interference suppressor has high performance in a large span of the parameter space [2].

In this paper, a novel algorithm was proposed to subtract power line interference (PLI) from contaminated ECG signal. Firstly, some PLI values were calculated from ECG signal in linear segment. Secondly, using nonlinear regression and least squares estimation, sinusoidal parameters such as frequency and phase were estimated from the calculated PLI values. Thirdly, the PLI values in the nonlinear segment closest to the linear segment were determined by the sinusoid function with the estimated parameters. Lastly, PLI was subtracted from the contaminated ECG signal in nonlinear segment. The experiment results show that the proposed method can more effectively remove PLI from ECG signal than other algorithms when PLI frequency fluctuates, and do not distort the shape of ECG signal [3].

This paper presented a new kind of design method of digital filter in order to eliminate the 50Hz noise. The filter was realized by software implementation in VC++ environment, and, simulated by MATLAB. To design 50Hz notch filters, system function was directly determined on the basis of given parameters, and use finite impulse response (FIR) filter or infinite impulse response (IIR) filter to approach design requirements. Experimental results show that algorithm could remove power-line interference effectively, and its operation was simple and applicable [4].

In this paper, a new method was proposed for removing power line interference in ECG signals based on EMD and adaptive filter. 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 analyse signal with excellent time resolution. Least mean square (LMS) algorithm developed by Window and Hoff is the most widely used adaptive filtering algorithm which is simple and powerful. Results indicate that the method is powerful and useful and the power-line interference can be eliminated from the ECG signal without affecting its spectrum [5].

A novel power-line interference (PLI) detection and suppression algorithm was proposed to pre-process real time electrocardiogram (ECG) signals. This algorithm first compares the energy at the harmonic frequency against the energy at neighbouring 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 [6].

This paper adopts independent component analysis (ICA) to remove this interference. The aim of ICA is to separate mutually independent components from mixed signal, which is linear combination of a set of mutually independent source signals. With the characteristics of extracting the independent component, ICA has been widely applied in biomedical signal processing, mixed-

signal separation, image de-noising and so on. ICA algorithm is applied to remove the interference of ECG signal, can not only preserve the original details information as soon as possible and filter the interference signal successfully, with good result. The experimental results showed that removal of interference of ECG signal Based on independent component analysis, can not only preserve the original details information as soon as possible and also filter the interference signal successfully [7].

A new linear segment determination rule was presented, by which linear and non-linear segment can be distinguished within single PL period by using the symmetry of sinusoidal wave. Correlation algorithm is used to calculate the amplitude and initial phase of Power Line Interference (PLI). Performance of the proposed algorithm is compared with and Subtraction Procedure (SP) on MATLAB platform. The presented algorithm evidently improves PLI evaluation update times, and avoids boundary distortion, and efficiently eliminates PLI. Experiment results show that the new algorithm is superior in filtering amplitude-changed PLI [8].

This paper presents an adaptive noise cancellation system for ECG signal base line filtering and power interference suppression, constructs an iterative time LMS algorithm combining variable and fixed step size, which effectively solves the problems of filtering SNR and convergence rate. The experiment results showed that this method improves 26.36dB in SNR, eliminates base line drift and power interference effectively, extracts ECG signal accurately and converges quickly, has important practical value in medical clinical diagnosis [9].

The paper presents an improved LMS algorithm of variable step length based on Kwong least mean-square algorithm. The algorithm proposed is used for an adaptive noise canceller. The sinusoidal signal and audio signal with Gauss white noise were simulated in noise cancellation system on the MATLAB platform. It has fast convergence and good noise suppression ability than traditional algorithms. Finally, an adaptive noise cancellation system employed DSP chip TMS320VC5509A, audio decoder chip TLV320AIC23 and related peripheral circuit was constructed; Using CCS3.3, and through the hardware emulator download link, the new algorithm improved LMS was used [10].
In this paper, an existing adaptive interference canceller is modified by considering the error at the neighbouring samples in estimating the power line interference parameters. The performance of the modified adaptive canceller is further improved by using error filtering and adaptation blocking. The windowed adaptive canceller (WAC) proposed in this paper 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) [11].

II. METHODOLOGY

All The basic idea for the adaptive filter is to predict the amount of noise in the primary signal, and then subtract that noise from it. The prediction is based on filtering the reference signal *x(n)*, which contains a solid reference of the noise present in the primary signal. The noise in the reference signal is filtered to compensate the amplitude, phase and time delay and then subtracted from the primary signal. The resulting signal is called an error signal *e(n)*, and is the output of the system. Ideally, the resulting error signal would be only the desired portion of the primary signal. The adaptive filter can be realize on DSP Processors because they have huge number of applications in today's life, such as audio signal processing, image signal processing, statistical signal processing, and biomedical signal processing. DSP is widely used in high speed modems and mobile phones also due to availability of low cost DSP chips that can perform extensive computation in real-time.

The interference is commonly modelled as an additive signal. Therefore, the measured corrupted signal is the sum of the signal of interest and the interference. An ideal power line interference suppression method should eliminate the power line interference while preserving

the signal of interest. For this purpose, notch filters and adaptive interference cancellers are two different approaches which can be used. Notch filters reduce the power line interference by suppressing predetermined frequencies.

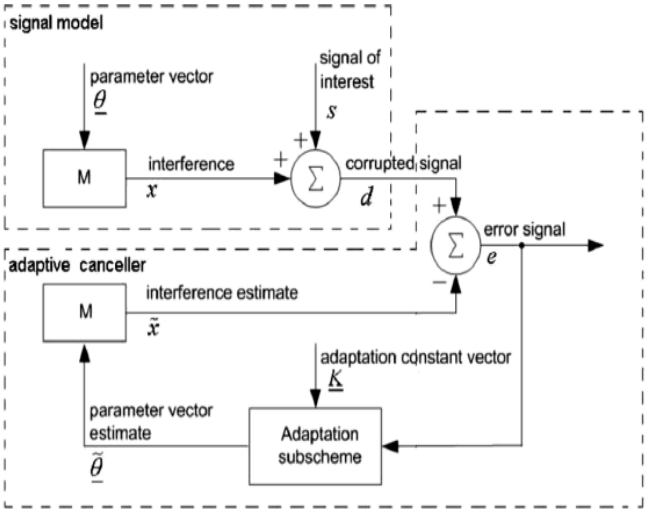

Figure. 1. General Structure of Adaptive Interference Canceller

Usually, an infinite impulse response (IIR) filter is adopted. The magnitude and phase spectrum of the ECG signal are less affected by narrow suppression band filters. Therefore, the suppression band of the notch filter should be as narrow as possible. However, this leads to problems whenever the power line frequency is not stable or not accurately known, a mismatch between the suppression band and the power line frequency might lead to inadequate reduction of the power line interference.

Adaptive interference cancellers have a general structure as shown in Fig. 1, that consist of the interference signal, the signal of interest, and the corrupted signal. The interference can be represented as a known function of the interference parameter vector. If input signal is a sinusoid, for instance, the interference parameter vector may contain its amplitude and phase. An interference estimate is internally generated as a function of the estimated parameter vector. The error signal is the difference between the corrupted signal and the estimated interference, and it is processed by an adaptation sub-scheme in order to find an estimate of frequency. The sub-scheme behaviour depends on the adaptation constant vector. It is common practice to assume and to be uncorrelated and configure the adaptation sub-scheme such that the mean-squared error (MSE) is minimized. This is referred to as least mean square (LMS) estimation. After convergence, the error is an estimate for the signal of interest which is the ECG signal.

III. CONCLUSION

In this review paper, the research work done by several authors has been put forward. From all the work done and discussed here, we can deduce that to remove Power line interference, the adaptive filter techniques are found to be the most appropriate. The adaptive filter can adjust its filter coefficients according to the adaptive algorithm in such a manner that the error signal is minimized. In future, DSP Processor TMS320C6713 DSK can more simplify this work by using several algorithms, for adjusting the weights of filter coefficients of the adaptive filter in order to reduce the mean square error (%MSE) parameter between the input signal and reference signal.

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