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Removing residual power-line interference using WHT adaptive filter

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Abstract – **Power-Line interference is a common phenomena in low-frequency biophysical measurement. The usual ways of solving this is the used of fixed bandwidth in analog or digital notch filter. However, these methods are not very suitable for the power-line interference frequency is non-stationary. In this paper, an effective adaptive filter structure is proposed to minimize the residual power-line interference without lost of reality. In order to obtain a satisfactory and acceptable convergence performance, WHT transform is used in the ADF. Throughout many clinical measurements, the result of this structure is effective in eliminating EMI/EMC interference.**

Keywords **– Power-line interference, WHT transform**

I. INTRODUCTION

In low frequency biophysical measurement, power-line interference is a major interference source. This interference is coupled into the measurement system from a variety of path [1]. Thus, to solve this problem using only hardware circuit is not enough and is not effective. Nowadays, adaptive filter is suggested to solve this problem. However, it is rather difficult to obtain the original interference source and the currently used biomedical equipments do not have an outlet to provide this interference signal. This situation is a great bottleneck for using digital signal processing to detect low frequency power-line interference. Practically, this interference signal is non-stationary. Many suggested digital processing methods have failed to solve this problem for their works were based on the assumption that this interference noise is stationary. To solve this, we proposed an effective adaptive structure [2]. With this structure, we extract the interference component from the input biomedical signal, pass it over to an adaptive filter, and obtain the required biomedical signal with minimum lost of reality. After few clinical trials, we found that it is satisfactory and acceptable. However, to overcome the continuous changing frequency of power-line interference and to get a better convergence rate, transform domain adaptive filter (TDADF) is used.

II. METHODOLOGY

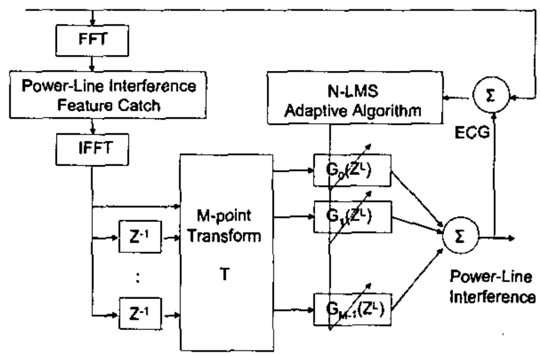

Fig.1. The structure of TDADF for removing power-line interference

Fig.1 is the adaptive structure for removing power-line interference. 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 first processed by FFT. And extract the significant interference bandwidth spectrum. Then IFFT is performed to recover the interference signal and used as the reference input. Before the reference input is feed into the TDADF, it is transform by a Walsh-Hadamard transform (WHT) [3], to obtain a better spread for the eigen values of autocorrelation matrix. 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.

III. RESULTS

First, an original clear ECG pattern is corrupted intentionally to behave like a non-stationary signal resembling the non-stationary power-line interference ECG. Then, structure of ADF and TDADF with NLMS are used to eliminate the power-line interference. The length of FFT for interference extraction is 256. Table I is the mean square error (MSE) for ADF and TDADF for different combination of filter taps and step size. The interference frequency changes once every 10 second. Table II is the MSE when interference frequency changes once every 15 second.

From Table I and II, when the interference signal frequency increases rapidly, the MSE of TDADF is better than that of ADF. Moreover, the MSE of TDADF is not sensitive with the changing of filter taps.

Fig. 2(a) is the ECG signal added with simulated power-line interference and its FFT, Fig. 2(b) is the ECG result after removing power-line interference and its FFT. This figure clearly shows the eliminating effect of TDADF.

TBALE I the mean square error with ADF and TDADF processing where power-line interference frequency changes once every 10 second

Taps	Step Size	MSE	
		ADF	TDADF
16	0.1	3.8836	3.5619
	0.2	2.6290	2.2887
	0.5	1.2277	1.1148
32	0.1	3.7214	3.4305
	0.2	2.4476	2.2643
	0.5	1.1560	1.1029

TBALE II the mean square error with ADF and TDADF processing where power-line interference frequency changes once every 15 second

Taps	Step Size	MSE	
		ADF	TDADF
16	0.1	3.9387	3.5691
	0.2	2.7393	2.1367
	0.5	1.2706	1.2024
32	0.1	3.8301	3.5166
	0.2	2.5524	2.1924
	0.5	1.2474	1.1043

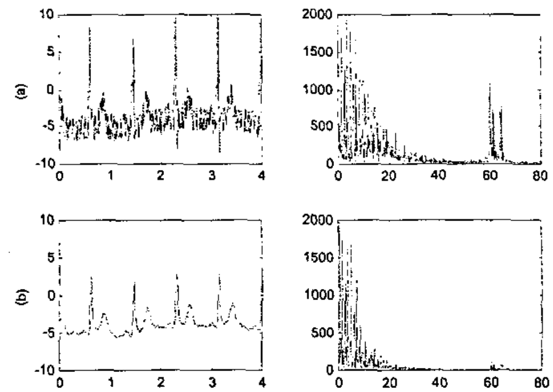

Fig.2 (a) ECG with power-line interference and its FFT

(b)ECG after removing interference and its FFT

IV. CONCLUSION

After a series of tests, the result shown that the proposed structure is capable of solving the problem of power-line interference on biomedical signal. This is especially ally significant with the use of TDADF. Moreover, TDADF also improve the convergence rate and useful in clinic for biomedical signal measurement.

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