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Performance Comparison of Modified LMS and RLS Algorithms in De-noising of ECG Signals

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ABSTRACT

The electrocardiogram (ECG) is generally used for the diagnosis of cardiovascular diseases. In many of the biomedical applications it is necessary to remove the noise from ECG recordings. Several adaptive filter structures are proposed for noise cancellation. The main objective of our work is to develop an adaptive algorithm to remove the contaminating signal and to obtain original ECG data. A new, simple and efficient Least Mean Squares (LMS) based adaptive algorithm developed for optimal removing of interference in ECG signals is introduced. It uses a modified LMS (mLMS) algorithm to adjust filter weights according to non-stationary properties of processed signal. Furthermore, simulation studies shows that the modified LMS algorithm gives better performance compared to an existing RLS algorithm in de-noising of ECG signals.

Keywords: *Adaptive algorithm, Adaptive filters, Electrocardiography, Noise cancellation*

I. INTRODUCTION

Electrocardiogram (ECG) is one of the important techniques for the diagnosis of heart diseases. Recorded ECG signals often interfere with a noise having non-stationary properties. The goal for ECG signal enhancement is to separate the valid signal components from the contaminated signals.

The existing recursive least squares (RLS) algorithm has generally faster convergence than LMS but it demands more computational complexity. In this paper we have proposed a normalized sign vector variable step size LMS algorithm that has both the faster convergence rate as well as less computational complexity. The performances of the RLS algorithm and the proposed normalized sign vector variable step size LMS algorithms are compared. We have shown that the proposed mLMS algorithm overcomes the limitations of RLS algorithm by using a normalized vector variable-step-size LMS algorithm and the *signum* of the input signal and thus performs better in de-noising of ECG signals.

II. SURVEY OF RELATED WORK

An adaptive recurrent filter structure is used for acquiring the impulse response of the normal Q,R,S waves. This method is applied to the detection of P-waves [1]. Normalized LMS (NLMS) algorithms takes into account a variation of the signal level at the filter output and select the normalized step size parameter that results in a stable as well as fast converging algorithm [2].RLS algorithm is another class of adaptive algorithm. This algorithm is used in adaptive filters to find the filter coefficients that relates to producing least mean square of the error signal between the desired$d(n)$and actual signal, $x(n)$[3].

III. PROBLEM STATEMENT AND MAIN CONTRIBUTION

The RLS algorithm gives superior performance compared to other adaptive algorithms as it has a faster rate of convergence but at the cost of computational complexity which is a severe drawback in biomedical applications.

Our research question is whether normalized sign vector-variable-step-size mLMS algorithm performs at least equally well as RLS algorithm with less computational complexity. We hypothesized that the convergence rate, mean, variance and execution time of mLMS algorithm are better compared to RLS algorithm.

The main contributions of this paper are to design, and implement the mLMS algorithm and then simulate it in MATLAB for Adaptive Noise Cancelling (ANC) in de-noising ECG signals. The performance of mLMS algorithm is then compared with the performance of RLS algorithm and the results are analyzed.

IV. PROBLEM SOLUTION

Modified LMS Algorithm

LMS based ANC system with filter length L is shown in

Fig. 1,where $d(n)$is the primary input signal, $x(n)$ is the reference input signal and$e(n)$is the error signal. The primary input contains ECG signal $s(n)$and thenoise $v(n)$. The reference signal is applied to the adaptive filter, which is correlated with $v(n)$ but not with $s(n)$.

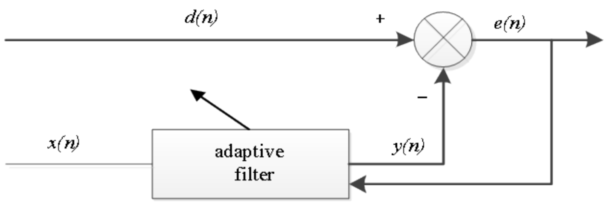
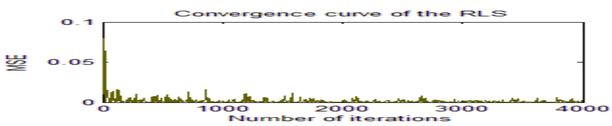
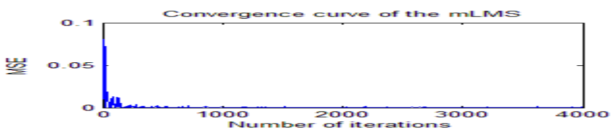


Fig.1.LMS based ANC system.



(a)



(b)

Fig.2.Convergence characteristics of two algorithms (a) RLS algorithm (b) mLMS algorithm.

The adaptive filter output is given by:

$$y(n) = \overline{w}^T(n)\overline{x}(n) \quad (1)$$

Where, $\overline{w}(n) = [w_0(n) w_1(n) \ldots\ldots w_{L-1}(n)]^T$is the filter coefficient$\overline{x}(n) = [x(n) x(n-1) \ldots\ldots x(n-L+1)]^T$ Since the signal and noise are uncorrelated, the Mean Squared Error (MSE) [2] becomes

$$E[e^2(n)] = E\left[\left(s(n) - y(n)\right)^2\right] + E[v^2(n)] \quad (2)$$

The basic weight update equation of LMS algorithm is:

$$\overline{w}(n+1) = \overline{w}(n) + \mu(n)\overline{x}(n) \quad (3)$$

Where, $\mu(n)$is the fixed step size. Then LMS algorithm uses variable step size vector which is an extension of LMS. This variable step size method used in the system increases step size with high MSE in order to achieve optimum weight quickly. The variable step size is given by

$$\overline{\mu}(n+1) = \alpha \cdot \overline{\mu}(n) + \beta \cdot e^2(n) \quad (4)$$

Where α, β are experimental constants $0<\alpha<1$ and $\beta>0$. Proposed mLMS algorithm also makes use of the *signum* of the error signal or the input signal, enabling a significant reduction in computing time. Finally weight update equation of mLMS is given by

$$\overline{w}(n+1) = \overline{w}(n) + \frac{\overline{\mu}(n)}{\|x^2(n)\|} sgn\,[e(n)]\overline{x}(n) \quad (5)$$

V. IMPLEMENTATION AND RESULT

In this project, we took an ECG signal of 4000 samples from MIT-BIH Arrhythmia Database and to make the primary input signal$d(n)$, added a uniformly random noise with variance 0.002 with it. A uniformly random signal with variance 0.0025 was used as reference input signal $x(n)$, and the constants α and β as 0.4 and 0.03.

The mLMS and RLS algorithms are simulated in MATLAB. The computational complexity and convergence characteristics of the two algorithms are shown in Table I and Fig. 2.

Fig. 3 shows the performances of two algorithms in estimating the desired signal under similar conditions. From Fig. 3, we can say that mLMS algorithm is successful in preserving P-QRS-T complexes of ECG signal. From Table I and Fig. 2, it is observed that mLMS algorithm is superior to the RLS algorithm in de-noising ECG signal with lesser computational complexity.

VI. CONCLUSION

Blind Signal Separation and Independent Component Analysis is a powerful and useful statistical tool for extracting independent source given only observed data that are mixtures of the unknown sources. The efficiency of the proposed method of Independent Component Analysis, has been tested with simulated signals as well as with clinical EEG. Theoretical Investigation and experimental results indicate that ICA constitutes a comprehensive and promising tool for the signal processing and control.

REFERENCES

[1] S N. V. Thakor and Y. S. Zhu, “Applications of adaptive filtering to ECG analysis: noise cancellation and arrhythmia detection,” *IEEE Transactions on Biomedical Engineering*, vol. 38, no. 8, pp. 785-794, 1991.

[2] M. Z. Rahman, R.A.Shaik andD. V. R. K .Reddy,“Cancellation of artifacts in ECG signals using sign based normalized adaptive filtering technique ”, in *2009 Symposium on Industrial Electronics & Application*, Kualalumpur,2009, pp. 442-445.

[3] S.Z. Islam, R. Jidin and M.A.M. Ali, " Performance study of adaptive filtering algorithm for noise cancellation of ECG signal'', in *7th International Conference on Information, Communication and Signal Processing*, China, 2009.

TABLE I
PERFORMANCE CONTRAST OF mLMS AND RLS ALGORITHMS

Parameters	mLMS	RLS
Mean	0.0057	0.0125
Variance	0.86	0.55
Multiplications	$2N+3$	$3(N+1)^2+3(N+1)$
Additions	$2N+2$	$3(N+1)^2+3(N+1)$
Time elapsed	5.5 ms	9.8 ms

N=number of samples taken; Time elapsed=time require to compute.

