Robust Cancellation of EEG from the Surface of ECG by using Modified Linear Iterative Kalman Filter

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Abstract— In Biomedical engineering, Electrocardiograph (ECG) has a key importance to diagnose the heart diseases. While acquiring the ECG signal, an Electroencephalography (EEG) interferes the desired ECG signal, due to which the true information cannot be retrieved. In this paper, the modified Iterative Version of Adaptive kalman and Recursive Least Square (RLS) Adaptive Filtering algorithms are used to cancel out the effects of EEG from the surface of ECG signal. Simulation results show that the Modified version of Iterative Kalman algorithm provides robustness as well as good tracking performance than RLS filtering algorithm.

Keywords— Modified iterative Kalman, recursive least square (RLS), Electrocardiograph (ECG), Electroencephalography (EEG).

I. INTRODUCTION

The actual interference EMG is due to the activity of the physique muscles on the surface of electrocardiography (ECG) is a main problem that provides a sound impacting on their evaluation [1]. To record an ECG signal, exterior electrodes are placed around the chest of patient with the help of the gel to enhance the conductivity of chest exterior. After documenting the ECG signal, which is generally passed to the amplifier to enhance the magnitude because ECG alerts are generally voltages of low magnitude (normally 0.0001 to 0.003 volt). Amplification of low voltages ECG with interferer EEG signal make analysis complicated [2]. Irrespective of efforts to reduce noise on the source by way of suitable pores and skin preparation and also using efficient productive electrodes for signal recording, some noises will often also go along with the desired indication [3]. As the heart is often a muscle, the particular frequency of the EMG at specified instant will be same like the ECG frequency. The issue associated with EMG disturbance removing is especially a result of the substantial overlap involving the EMG disturbance signal and this in the regarded ECG signal. The particular spectral filtering approach (i.e. low pass, high pass) is just not pertinent; this may rectify a considerable portion of the ECG data as it eliminates all of the components of a chosen rate of frequency in above case components of both ECG and EMG. Intended for this sort of environment adaptive filtering algorithms usually are recommended and in which estimation is performed by applying a supplementary EMG referrals which compare the EMG template with the interference signal to subtract the undesired signal. Seeing this it is known that EMG-contamination induces huge errors with respect to the amplitude and regularity from the natural indication, specifically for low-activity signals.

From the last decade, research regarding to biomedical signal processing is an important topic which is still under discussion, many adaptive filtering algorithms are purposed till today for noise cancellation in biomedical signal, however, the convergence performance is one of the major issues. In [4] and [5], low complexity normalize least square (NLMS) based adaptive filtering algorithm is used which provides slow tracking performance while removing the noise from the desired biomedical signal. The presented algorithm in [6] despite having enormous computational complexity is also unable to achieve the robust cancellation of noise in biomedical signal. Although, the above mentioned work is quite revolutionary but does not provide an optimal solution which robustly removes the noise artifacts from the surface of ECG signal. In this paper, a Modified Iterative version of adaptive kalman Filter is used to cancel out the EMG artifacts from the surface of ECG and compared with the Recursive Least Square (RLS) adaptive filtering algorithm. It is realized that the modified iterative kalman filter provides robustness as well as good tracking performance than RLS adaptive filtering algorithm. This paper is organized in following etiquette, In section 2 channel model is discussed, section 3 precisely describe the Adaptive Filtering Algorithms, and section 4 present in the comparison in form of simulation results.
II. SYSTEM MODEL

A. Noise cancellation model

Biomedical signals are very important to diagnose the diseases of human body. Due to internal or external undesired signals the original information could not be retrieved, effectively. In such cases, finite impulse response (FIR) based adaptive filtering technique is used to cancel out the undesired signals from the sensitive biomedical signals. The FIR based noise cancellation model is shown in Fig. 1.

\[ y(n) = u(n) + v(n) \]  
\[ y(n) = \sum_i v_i'(n)w_i(n) \]  
\[ e(n) = x(n) - y(n) \]

B. Selected adaptive filter

Adaptive filters are very important to remove the undesired signal from the desired biomedical signals. RLS [7] based adaptive filter works on the forgetting factor \( \lambda \) and recursively compute the estimate of the desired signal which is depended on the kalman gain and error covariance, on the other hand, the modified iterative kalman [8] is the modified version of [9] which is also works on kalman gain and error covariance that makes the adaptation of the filter fast. The algorithms for RLS and modified iterative Kalman filter are shown in Table. 1 and Table. 2, respectively.

III. SIMULATION RESULTS

In this section, the simulation results are performed to analyze the behavior of Recursive least square (RLS) and modified iterative version of adaptive kalman algorithms.
while removing the EMG signal from the surface of ECG signal. The convergence and tracking performance are two measures which are to be considered in the conducted simulation. In the simulations, the filter order is taken to be 60 taps. In case of RLS filter, the value of the forgetting factor lambda is chosen 0.99. Fig. 1 (a) shows the matlab based ECG wave form which is basically the graphical recording of the activity of heart. The mixed ECG and EMG signal is shown in Fig. 1(b) and it is visualized that at the surface of ECG signal the true information can’t be retrieved clearly. Fig. 2 and 3 show the tracking performance of RLS and modified iterative Kalman filters, respectively. From the simulation results, it is analyzed that the modified iterative Kalman provides robustness and it tracks the desired signal with 270 iterations, on the other hands, RLS adaptive filter converges at above 300 iterations, although, it is seen that the tracking performance is not good at all iterations.

IV. CONCLUSION

A framework about the performance comparison of RLS and modified Kalman has been analyzed while remove the EMG artifacts from the surface of ECG signal. The modified iterative kalman provides robustness, lesser error variance and better tracking performance than RLS adaptive filter. The modified kalman takes 270 iterations to track the desired biomedical signal, on the other hands, RLS takes 300 independent trials but good tracking performance is not to be seen at all iterations.

REFERENCES


