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Removal of Power Line Noise from EMG Signals Using Rls Algorithm

Vahini Sri MA
M.E (Applied Electronics), Prist University,Thanjavur

ABSTRACT

Electromyography (EMG) is a test used to discern primary muscle conditions from muscle weakness caused by neurological disorders. The noise which do have frequency of contaminating the EMG signals. The objective of this research was to remove or reduce the main noises which disturb the EMG signal with help of filtering. The most common noises which are present in the EMG signal are the power line interference (PLI) and electrocardiography (ECG). RLS algorithm is used for removal of PLI artefacts from the main EMG signal and artificial neural network (ANN) which give the error signal (i.e. range difference between the actual and target values) and enhance the signal-to-noise ratio (SNR) of the output signal.

***Keywords*: Digital Filters, Electromyogram (EMG), RLS Algorithm, PLI.**

I. INTRODUCTION

With the help of Electromyography (EMG) we can diagnostic test of human body in a reliable nature. An electromyography (EMG) which finds the electrical potential generated by muscle cells when these cells are electrically or neurologically activated. EMG is highly used to distinguish between the primary muscle conditions from muscle weakness caused by neurological disorders. It is also used to find causes of paralysis, weakness, involuntary twitching and abnormality levels of muscle enzymes [5]. It helps to diagnose nerves disorder and damages and cracks in muscles. The signal are a function of time and is describable in terms of amplitude, frequency and phase. Electrical impulses are shown as wavelike structure on a monitor device and recorded as an electromyogram (EMG). The signals produces by EMG are unique in nature and it supposed to distinct biologically. The characteristics EMG signal which states no infection to the patient as follows:

i. The Amplitude of the signal ranges between: 0-11 mV.
ii. Dominant energy of the EMG in the range of 50-150 HZ.
iii. The usable energy of the signal is limited to the 0 to 500 Hz frequency range.
iv. Bandwidth of the EMG signal is in the range of: 20-2000 Hz.

II. NOISES OR ARTIFACTS IN EMG

In general, noise is defined as electrical signal that are not the part of the desired signal. The EMG signal depends on the anatomical and physiological properties of muscles. It acquires noise while travelling through different tissues. Due to the presence of different types of the noise which are occurring in the EMG signal (during the conduction of the EMG test) destroy the important information regarding the diseases. Biomedical signals are often contaminated by noise from sources such as power line interference and disturbances due to movement of recording electrodes. With the addition of these noises the biomedical signals are often interfere with one another, e.g., signals due to muscles contractions often contaminate electrode encephalograms (EEG‟s) and electrocardiograms (ECG's). ECG, which is frequently present when EMG is recorded from electrode sites near the trunk and neck area. These noises alter the real shape of the original EMG signal. For removing these noises digital filters are used. Therefore filters play an important role in the medical field for removing noise and interference. Noise removal is complicated process because the characteristics of almost all biomedical signals vary in time. There are number of reasons, due to which noise signal is introduced in to the EMG signal. The EMG detector, if it is at the surface of the skin, collects signals from different motor units at a time which may generate interaction of different signals. A primary source of noise is the electrical or magnetic signals produced by nearby devices and power lines as human body behaved like an antenna which caught electromagnetic interference signals [14]. Moreover, inaccuracies in the sensors, poor contact between sensor and source (patient), and disturbances from signals produced by physiological processes. The artifacts are the superimposed signal that can hide some useful information in a measured signal. It is important to understand the characteristics of the electrical noise. The main task of processing biomedical signals is to filter the signal of interest out of from the noisy background and to reduce the redundant data stream to only a few, but relevant parameters.

Several filtering techniques were developed to reduce the noises from the EMG signal in the past such as the low pass differential filter for the analysis of EMG signals is defined in [1]. High pass filter (HPF) is used in [2] to effectively remove ECG artifact from raw EMG and suggested that a cutoff frequency of approximately 30Hz is desirable for balancing ECG removal with excessive EMG. A simple method for removing power line artifact from EMG in the time domain is suggested in [3]. Two different methods were compared for their efficacy in removing 50 Hz noise. The first was a simple second-order recursive digital notch filter and the second method called spectrum interpolation, compared in [4]. Back propagation network, explains the concept of adaptive interference cancellation and efficiency of BPN to cancel the ECG interference in EMG signal is given in [5]. The Real-time filtering technique can be used to remove ECG interference from recorded EMG. The gating technique came in to use before the Real-time filtering [6]. Elimination of Power Line Noise from EMG signals using an efficient adaptive laguerre filter is suggested in [7]. In this paper a novel algorithm is proposed for cancelling the Power Line Interference (PLI) and its harmonics from Electromyography (EMG) signals using an adaptive IIR Laguerre filter. A de-noising method using independent component analysis (ICA) and a high-pass filter to effectively suppress the interference of ECG in SEMG recorded from trunk muscles is discussed in [8]. ICA analysis was applied to separate SEMG from ECG artifacts based on the assumption that muscle and heart activities are anatomically and physiologically separated processes and their independency is reflected in the statistical relation between the electrical signals generated by those processes is addressed in [9]. Also the artifacts removal can be performed by using Discrete Wavelet (DWT) or Independent Component Analysis, in this paper [10], the author present a method based on the joint use of wavelet transform and Independent Component Analysis. Three methods for offline removal of power line interference from electromyograms were suggested in [11]. To remove the ECG from EMG signal, adaptive filtering technique is used, ANC filter based on a RLS algorithm can adaptively track the filter coefficients according to the input signals, and it should maintain similar performance when applied to a variety of muscle groups. This adaptive filter was effective and efficient for noise cancellation of surface EMGs [12]. In the next, the authors present three methods of artifact removal: (a) Wavelet filter (b) Neural ICA filter and (c) the mixed Wavelet-ICA filter are addressed in [13]. To remove two noises which disturb the surface electromyography signal that is: ECG and PLI a new Lean Mean Square (LMS) Widrow adaptive structure is proposed in [14]. RBF neural network as compared with other types of neural networks can be effectively remove the noise from EMG is explained in [15]. A new method is designed based on filtering of EMG signal corrupted with interference of power line and ECG (EMG+PLI+ECG), by using Matching Pursuit (MP) is given in [16].

A. POWER LINE INTERFERENCE REMOVAL FROM EMG SIGNAL

A major problem in the recording of EMG test is that the measured signal is corrupted by 50 Hz power line interference. Many methods were proposed in the past for the removal of power line interference. It occurs in the middle of the EMG spectrum and comes from both electric field and AC power lines. Notch filtering is very powerful method which is used to remove the power line noise. This filter is very important in a wide variety of instrumentation applications, from telecommunications to biomedical signals processing, where often it is necessary to remove a narrow band or even a single frequency of the measurement signal. It is so far known that IIR adaptive notch filter realization performs better than finite impulse response (FIR) counterparts as regards the number of coefficients and computational complexity. A notch filter removes a particular frequency from a signal and has a frequency response that falls to zero over a narrow range of frequencies (i.e. a 50 Hz notch may block signals from 49.5 –50.5 Hz)

III. DESIGN OF PROPOSED MODEL

The objective of this work is to design a new technique to remove the artifacts from the EMG signal so that physician gets good quality of EMG signal. In order to full fill this objective, the number of task should be performed and work procedure to be adopted for this proposed work is as follows:

Step:1 Download the data (EMG data) from the Physio.net of all the subject. The data should be Mat lab compatible i.e. data.mat file.
Step:2 Load the signal in Mat lab.
Step:3 Add synthetic Power line noise to the signal.
Step:5 Calculate the measured signal.
Step:6 Remove the unwanted signal or the characteristics from the signal using RLS algorithm.
Step:7 Take the signal from the previous step and apply it to the Artificial Neural Network.

A training pair is presented to the network. Neurons in each layer calculate the net value. At the output layer, get the error signal which is the difference between the actual and target values. By adjusting the weight values of the neurons in each layer the error can be minimized or so this is called the supervised learning. The algorithm which is used to weight updating is the gradient descent or back propagation algorithm. The speed and accuracy of the learning process depends on the learning rate. There are two phases of data flow. First, the input pattern is propagated from the input layer to the output layer and, as a result of this forward flow of data, it produces an actual output. Then the error signal is back propagated from the output layer to the previous layers to update their weights.

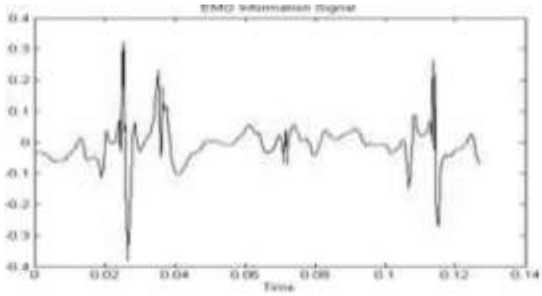

Fig.1 EMG signal

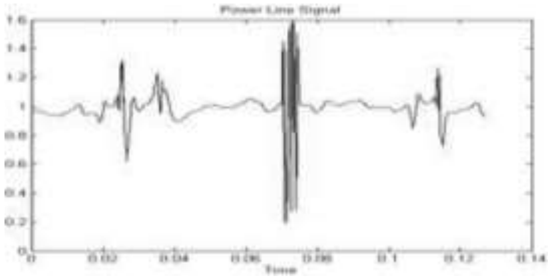

Fig.2 Power line signal

Fig.1 shows the EMG signal of a healthy person. Hence EMG signal is a complicated signal, which is calculated by the nervous system and is dependent on the anatomical and physiological properties of muscles. This is a waveform of 44 year old man without history of neuromuscular disease. Fig.2 shows the Power Line signal which acts as the noise in the main EMG signal.

A. RLS ALGORITHM

The objective here is to choose the coefficients of the adaptive filter such that the output signal during the period of observation, will match the desired signal as closely as possible in the least- squares sense. The minimization process requires the information of the input signal available so far. Also, the objective function we seek to minimize is deterministic. The input signal information vector at a given instant k is given by

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$$\mathbf{x}(k) = [x(k)\, x(k-1) \ldots x(k-N)]^T$$

The RLS (recursive least-squares) algorithm, whose convergence does not depend on the input signal, is the fastest of all conventional adaptive algorithms. The major drawback of the RLS algorithm is its large computational cost. However, fast (small computational cost) RLS algorithms have been studied recently. In this paper we aim to obtain a faster algorithm by incorporating knowledge of the room impulse response into the RLS algorithm. Here, we study the RLS algorithm from the viewpoint of the adaptive filter because (a) the RLS algorithm can be regarded as a special version of the adaptive filter and (b) each parameter of the adaptive filter has a physical meaning. Computer simulations demonstrate that this algorithm converges twice as fast as the conventional algorithm. These characteristics may plays a vital role in biotelemetry, where extraction of noise free ECG signal for efficient diagnosis and fast computations, high data transfer rate are needed to avoid overlapping of pulses and to resolve ambiguities. To the best of our knowledge, transform domain has not been considered previously within the context of filtering artifacts in ECG signals. In this paper we present a RLS algorithm to remove the artifacts from EMG. This algorithm enjoys less computational complexity and good filtering capability.

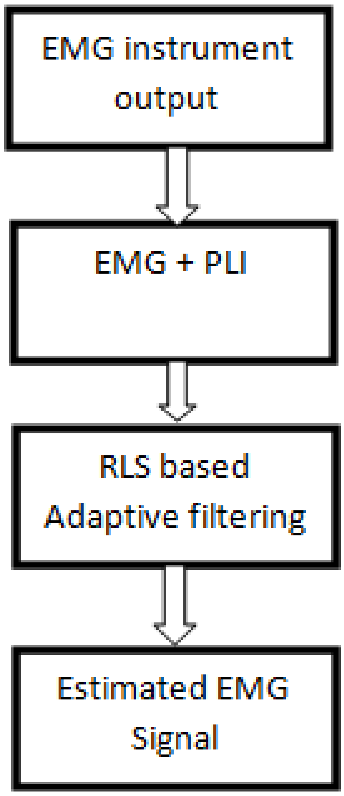

Figure.4:Flowchart for the proposed implementation

IV. SIMULATION RESULTS

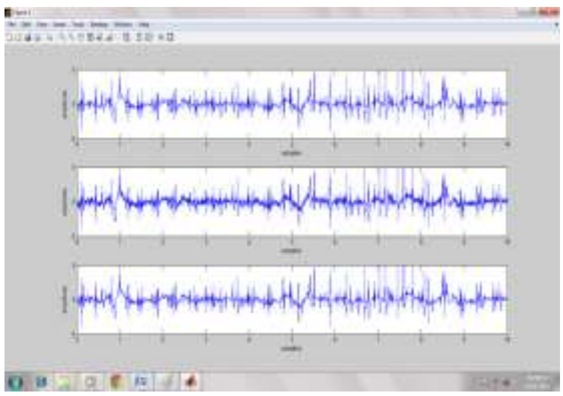

Fig.3 EMG signal (upper row), EMG signal with Power line noise (middle row), EMG signal after removal of PLI (lower row)

V. CONCLUSION

This paper proposes a novel algorithm get an estimated EMG signal which is free from the Power Line interference. The presence of artifacts in real signal can cause hindrance in its interpretation. It becomes an important task to pre-process the signal in order to keep the noise minimum. In this paper we present a RLS algorithm to remove the artifacts from EMG. This algorithm enjoys less computational complexity and good filtering capability. Now to automate this process, machine algorithm called BPNN (Back propagation neural network) is used and good results are obtained. In this research work the main motive was to get minimum square error close to zero so that the trained network has minimum possible unknown characteristics.

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