Comparative Study of FIR Digital Filter for Noise Elimination in EMG Signal

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Comparative Study of FIR Digital Filter for Noise Elimination in EMG Signal

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Abstract

In Performance of EMG Signal, Signal acquisition must be noise free. This paper deals with the application of the digital FIR filter on the raw EMG signal. In this paper different window techniques used to design FIR filter and their Signal to noise ratio, Power spectral density, Mean & Standard deviation are compared.

INTRODUCTION

In the example given below (Fig. 1), a raw surface EMG recording (EMG) was done for three static contractions of the biceps brachii muscle:

When the muscle is relaxed, a more or less noise-free EMG **Baseline** can be seen. The raw EMG baseline noise depends on many factors, especially the quality of the EMG amplifier, the environment noise and the quality of the given detection condition. Assuming a state-of-the-art amplifier performance and proper skin preparation, the averaged baseline noise should not be higher than 3 – 5 micro volts,

1 to 2 should be the target. The investigation of the EMG baseline quality is a very important checkpoint of every EMG measurement. Be careful not to interpret interfering noise or problems within the detection apparatus as "increased" base activity or muscle (hyper-) tonus.

The healthy relaxed muscle shows no significant EMG activity due to lack of depolarization and action potentials! By its nature, raw EMG spikes are of random shape, which means one raw recording burst cannot be precisely reproduced in exact shape. This is due to the fact that the actual set of recruited motor units constantly changes within the matrix/diameter of available motor units: If occasionally two or more motor units fire at the same time and they are located near the electrodes, they produce a strong superposition spike! By applying a smoothing algorithm (e.g. moving average) or selecting a proper amplitude parameter (e.g. area under the rectified curve), the non- reproducible contents of the signal is eliminated or at least minimized.

2. DIGITAL FIR FILTER

The most essential tool of Digital signal processing is a digital filtering. A filter is a device when a signal is given; it changes to some desired form by changing its shape, amplitude, frequency or phase. They are usually employed to remove the noise, extract information signals and separate two or more combined signals. Digital filters are extremely used in noise cancellation, echo cancellation and also in the field of biomedical engineering to remove unwanted noise from EMG, ECG and EEG. The digital filters are divided into two basic types, Finite Impulse

Response (FIR) and Infinite Impulse Response (IIR) filters, which are known as non recursive and recursive filters. In the FIR system, the impulse response is of finite duration where as in the IIR system, the impulse response is of infinite duration. IIR filters are usually implemented using structures having feedback, that's why the present response of IIR filter is a function of present and past values of the excitation as well as the past value of the response. But the response of the FIR filter usually implemented using structures having no feedback so the response depends only on the present and past values of the input only.

A. DESIGN OF FIR LOW PASS FILTER

In this work different type of window techniques has been used for reduction of the noise and comparing SNR, PSD & standard deviation, these techniques are equi-ripple filter, Kaiser Window function, Hanning Window Function, Chebyshev Window Function, Hamming window function and Bartlett window function.
In this design the minimum order of the filter are selected and other parameters like Sampling frequency -4000 Hz,
Pass band frequency 500Hz, Stop band frequency 1000 Hz,
Pass band attenuation 1dB, Stop band attenuation 80 dB,
Density factor 20. The response is shown below in figures.

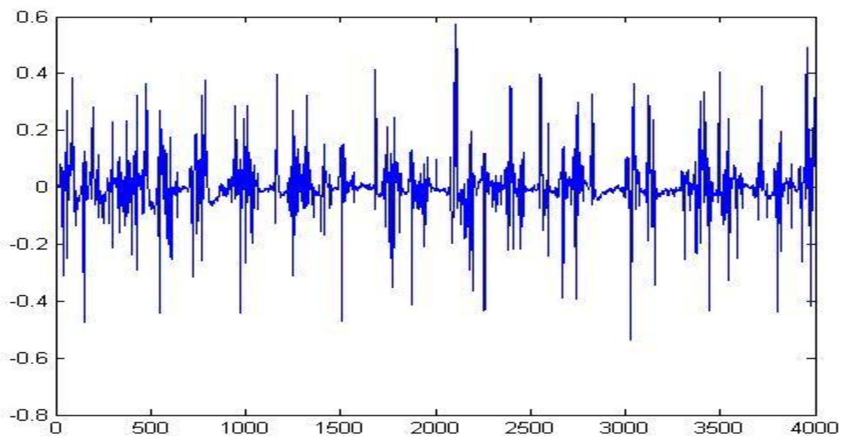

Figure1-Normal EMG waveform.

3. METHODOLOGY

In this paper noisy EMG signal are collected from three databases.The three examples of EMG data from: 1) a 44 year old man without history of neuromuscular disease; 2) a 62 year old man with chronic low back pain and neuropathy due to a right L5 radiculopathy; and 3) a 57 year old man with myopathy due to longstanding history of polymyosities, treated effectively with steroids and low-dose methotrexate. The data were recorded at 50 KHz and then down sampled to 4 KHz. During the recording process two analog filters were used: a 20 Hz high-pass filter and a 5K Hz low-pass filter. All signal are effected by noises and artifacts caused by some recourses. A low pass digital FIR filter designed for digitized signal at 4000 Hz per signal relative to real time [12].
The band pass-filtered signals were digitized at 4000 Hz per signal relative to real time using hardware constructed at the EMG. Three EMG data signals have a 40000 number of samples in 10 second. Sampling frequency of the data signal is 4000. Filter of noisy EMG data signal set up in two steps, in first step EMG input data signal extracted from the baseline drift and 10 db AWGN noise is introduced in input data signal as shown in figure 3. In the second step design a filter with the help of FDA tool in MAT LAB software and this noisy EMG data signal produce to as an input in designed filter with help of MATLAB coding. After the designing of filter, calculate the signal to noise ratio, power spectral density & standard deviation before and after filtering for window techniques, and compare these techniques on the basis of SNR, PSD & Standard deviation.
The test data results are compared in table -1 & table-2.

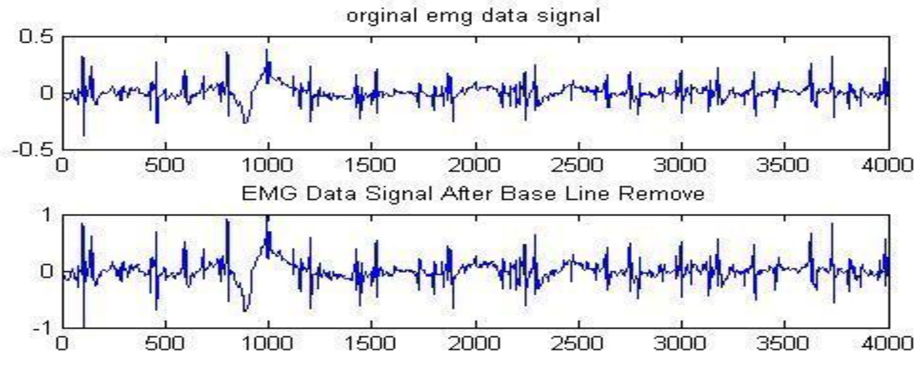

Figure 2-EMG signals with base line removal

4. RESULT

The results are calculated on EMG signals and accordingly, simulations are carried out on noisy EMG input and desired EMG signal. In this paper noise is reduced from different EMG data signals using FIR digital filter and SNR, PSD & standard deviation are calculated for various window techniques and compared these results before filtering and after filtering.

In this paper different EMG signals have been filtered by different FIR window techniques and their filtered values are used to calculate SNR, PSD & Standard Deviation. The aim of this paper is to find out the best window technique for different EMG signals and as we can see that in Table- 2, Bartlett window provides good results in terms of SNR(Signal to noise ratio),PSD(Power spectral density) & standard deviation for EMG signals.

Table 1:- SNRs, PSD & Standard deviation for EMG signal before filtering

EMG Database	SNR	PSD	Standard deviation
Healthy	8.2701	0.1318	10.8604
Myopathy	4.8785	0.1276	9.8134
Neuropathy	-9.1915	0.1135	13.2701

Table 2:- SNRs, PSD & Standard deviation for Different EMG signals after filtering

Window Function	EMG Database	SNR	PSD	Standard deviation
Kaiser window	Healthy	3.1943	0.0632	15.8604
	Myopathy	3.5958	0.0558	14.9366
	Neuropaty	4.1155	0.0440	13.2701
Hanning window	Healthy	2.7251	0.0704	16.7819
	Myopathy	3.0993	0.0625	15.8141
	Neuropaty	3.5.68	0.0506	14.2330
Chebyshev window	Healthy	2.8251	0.0688	16.5900
	Myopathy	3.2250	0.0607	15.5870
	Neuropaty	3.6372	0.0491	14.0209
Bartlett window	Healthy	2.5045	0.0741	17.2136
	Myopathy	2.8324	0.0665	16.3075
	Neuropaty	3.2100	0.0542	14.7275
Hamming window	Healthy	2.7300	0.0703	16.7725
	Myopathy	3.1009	0.0665	15.8112
	Neuropaty	3.5075	0.0506	14.2318

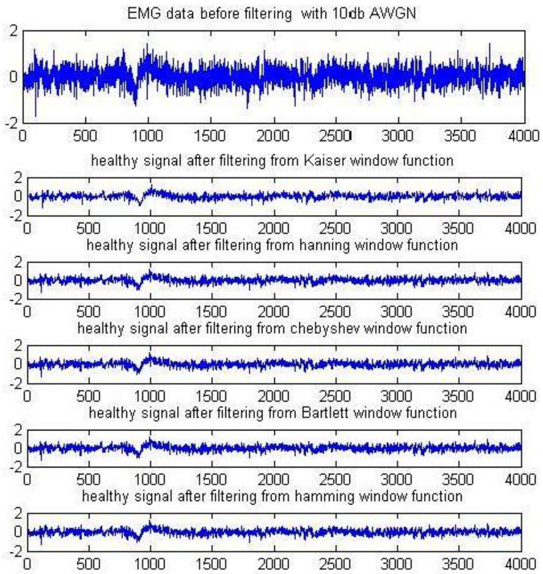

Figure 3- Noisy EMG healthy data signal and Filtered EMG healthy data signal using window Technique

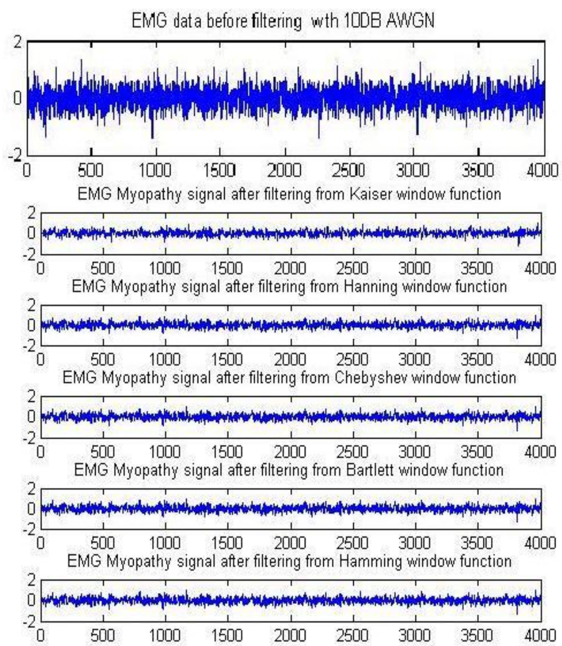

Figure 4- Noisy EMG myopathy data signal and Filtered EMG myoopathy data signal using different windows technique

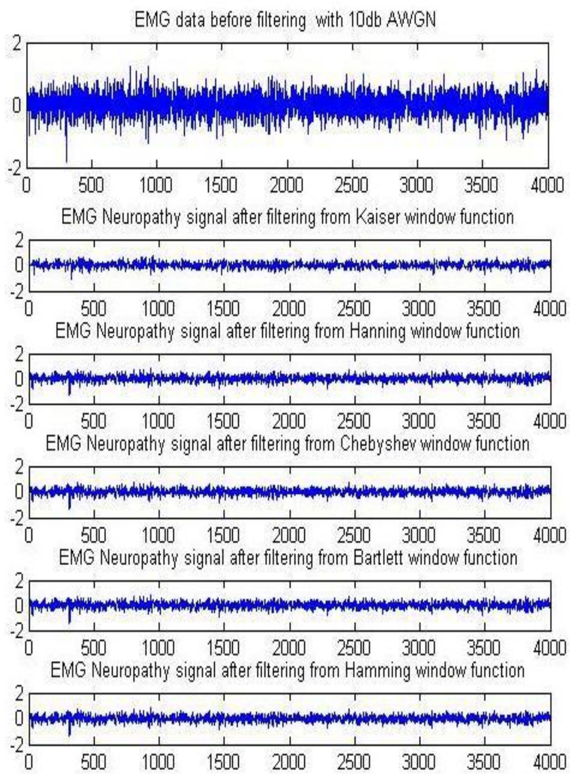

Figure 5- Noisy EMG neuropathy data signal and Filtered EMG neuropathy data signal using different windows technique

5. CONCLUSION & DISCUSSION

This paper is devoted to the problems and solutions on removal of Single Frequency Tones from Signals. The understanding of noise cancellation from EMG signal has been explained clearly using the techniques namely Kaiser, Hanning, Chebyshev, Hamming and Bartlett window techniques. It has been proposed a solution for high frequency noise interferences from original EMG signal, for Kaiser, Hanning, Chebyshev and Bartlett window function and results are compared on the basis of SNR, PSD & Standard deviation. So the Bartlett window has more noise reduction from noisy EMG data signal.

Table 1 and 2 has shown the SNR, PSD & Standard deviation before filtering and after filtering using FIR filter techniques. The results have been obtained which were required in purpose statement of the paper.

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