Digital filtering of mioelectrical signals from a person's forearm to probe accuracy of a physical electronic filter

Filtrado digital de señales mioeléctricas del antebrazo de una persona y comparación con un filtro electrónico físico

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Abstract

Nowadays electromyogram (EMG) signals have a big huge motion of robotic applications Such, prosthesis, study activity of muscles, etc. The study of These signals is Important So They Can Be Extracted and be applied on Several use. But on This process there are some limitations. Some of them, the low amplitude (order of millivolts) and common noise on EMG signals. It make us to do an effort to Improve and / or Eliminate some trivial signals possible. So the present work it is focus on the filtering of EMG signals and then a subsequent activities in Those results Could be used in some applications of interest like Those marked above. In This paper it is Stated the filtering stage in Matlab With some generic filters (low and high pass) filters and wavelet family. Syms wavelet filters are used in signal processing Widely. Data (signals) Were Collected from the forearm muscles, it is the first stage That Involves acquisition and filtering phase of the study. The contribution is the comparison Between to filter and electronic physical Those results from software. That information will help us to choose the correct one in order to Obtain clear and useful information and probe the accuracy of the physical filter implementation in order to continue back some applications.

Filters, EMG signals, Wavelet

Resumen

Hoy en día, las señales de electromiograma (EMG) tienen una gran cantidad de aplicaciones tales como movimiento robótico, prótesis, estudio de la actividad muscular, etc. El estudio de estas señales es importante para que puedan extraerse y aplicarse en varios usos. Pero en este proceso hay algunas limitaciones. Algunos de ellos, la baja amplitud (orden de milivoltios) y el ruido común en las señales EMG. Esto nos forza a hacer un esfuerzo para mejorar y/o eliminar algunas posibles señales triviales. Por lo tanto, el presente trabajo se centra en el filtrado de señales EMG y luego en actividades posteriores, los resultados podrían usarse en algunas aplicaciones de interés como las marcadas anteriormente. En este documento está programado la etapa de filtrado en Matlab con algunos filtros genéricos (paso altas y bajas) y filtros de familia Wavelet Symlets o Syms. Los filtros Wavelets Syms son ampliamente utilizados en el procesamiento de señales. Los datos (señales) se obtuvieron de los músculos del antebrazo en una primera etapa de investigación que consiste en la adquisición y el filtrado. De esta forma se contribuye con la comparación entre un filtro electrónico físico y los resultados del software. Esa información nos ayudará a elegir la correcta para obtener información clara y útil y probar la precisión de la implementación del filtro físico para continuar con algunas aplicaciones posteriores.

Filtros, Señales EMG, Wavelet

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Introduction

The electromyogram (EMG) is a common medical procedure that uses electrodes to detect and measure electrical signals from muscle activity, which may be useful in intelligent recognition of different movements of the limb of a person. The EMG signal has been used since 1948 with the performance of the prosthetic hand. Commercial production with myoelectric prosthetic hand signals began in 1957 at the Central Research Institute of Prosthetics Moscow to drive a stepper motor. Later in this scheme Control strategy myoelectric a simple control scheme on widely analyzed and developed and off(Kobrinsky, 1960) (Popov 1965).

From this it has developed a wide variety of control schemes to translate the EMG signal. The variety of control schemes are typically classified according to the nature of the control, as sequence control and simultaneous control. In schemes sequential control, the EMG signals are translated using the following schemes: 1) control on-off, 2) proportional control, 3) direct control, 4) control finite state machine, 5) based control recognition patterns, 6) position control schemes, and 7) control schemes regression(Geethanjali, Ray, & Shanmuganathan, 2009)

In the sequential control surface electrodes were used to connect signals to the prosthesis human control, thus is possible to identify three to four possible locations from the residual limb to acquire signals. Surface electrodes in modern myoelectric prosthesis often embedded in the prosthesis and make contact with skin. These electrodes detect EMG signals from the skin surface and amplify muscle action, voluntary muscle contractions in the residual limb and are used to control the movement and functions of the prosthesis, this technique is preferable because of its easy access and non-invasive procedure, however the skill of the prosthetic hand is lower due to the limitation in identifying locations to acquire signals. Instead collection intramuscular EMG signals is an invasive technique and requires surgical ability to use implantable myoelectric sensor. However Intramuscular EMG signals provide access for the collection of EMG signals from multiple locations to provide multiple levels of control to the prosthetic limb(Litcher, Lange, & Hedin, 2010) (Farrell & Weir, 2005).

Currently there is research aimed at replacing external electrodes implantable myoelectric sensors fully include a wireless interface to the prosthesis. It is intended that myoelectric sensor read EMG signals electrode amplified intramuscular recording and transmitted wirelessly to a receiver in the prosthetic limb, causing the implant to remain in use by rechargeable battery and a transfer link inductive energy prosthesis(Litcher et al., 2010). The following Table 1.1, cites some applied work on the electromyographic signals (EMG). The following Table 1 lists some applied on the electromyographic signals (EMG), where biomedical and electronic applications work stand out.

Author / Application	Description
(Geethanjali et al., 2009)/ Biomechanics	Development of a four-channel EMG for driving a prosthesis.
(Kobrinsky, 1960) [two] (Popov 1965)/ **Biomechanics**	Performance of a prosthetic hand by EMG signal.
(Litcher et al., 2010)/ **electronics**	EMG development of wireless sensor for controlling prostheses.

Table 1 documented work done with EMG

Since we have seen some applications due to the processing of myoelectric signals, it is necessary to know that many of these signals contain trivial information. Therefore, in this paper a signal filtering acquired for comparison and test the validity of a physical filter implemented develops.

The Fourier transform TF is a particular case of wavelet transform TW, this because the TF only analyzes signals in the frequency domain, unlike TW which makes both time domain and frequency. For versatility the wavelet filters were applied to analyze the results obtained by this technique since the capture myoelectric electronics are made in a domain standard frequency of 50 -500 Hz (by law), ie the frequency is ranging , so the TW filters are suitable for these applications, plus they are high-speed filters. After analyzing the big picture of the electromyographic signals, it is to use some of these tools to analyze EMG signals the best possible way. The methodology to be followed in this work is shown. (Louis, 2018) (Louis, 2018)

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Methodology to develop

This paper will be presented three main stages; applying filters lowpass and highpass, the filter effect Wavelet Syms and finally comparing the result of the above two steps with the result of a physical filter to the same signal. It will work with the signal obtained arm crude, ie, before passing through any physical filtration stage. The following figure is the signal represents the original signal, Figure 1.

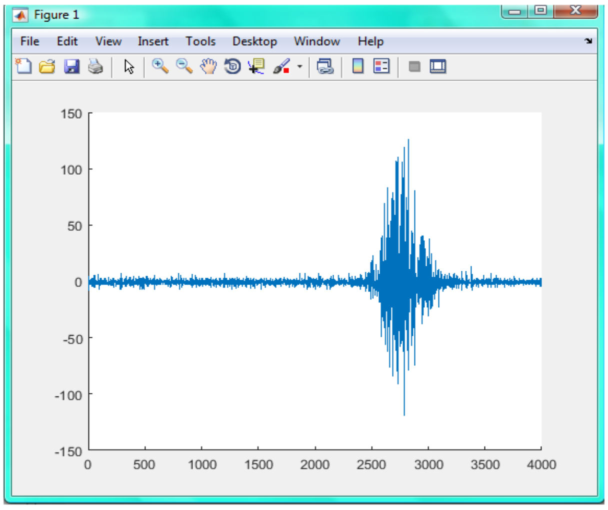


Figure 1 Representation of the original signal

The behavior of this signal is defined by approximately 4000 discrete values. Then it proceeds to do the filtering by some Matlab tools. It was applied one lowpass filter and one high pass, to attenuate some frequencies provided the cutoff frequency, 50 or 500 Hz for low and high frequencies.

The low pass filter allows signals below a cutoff frequency and attenuates signals above the cutoff frequency to smooth the signal high frequency noise.

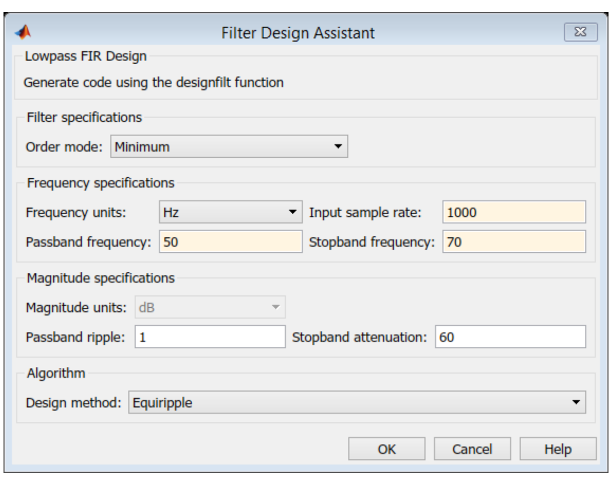


Figure 2 Characterization lowpass filter

In contrast the high pass filter attenuates signals or low-frequency noise, situated below the cutoff frequency to smooth the signal.

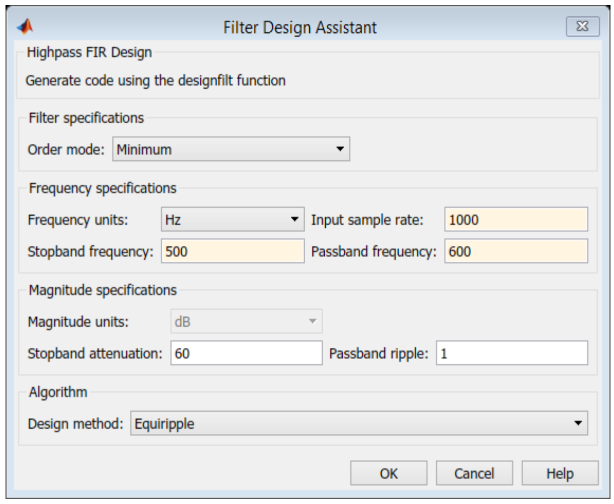


Figure 3 Characterization of the high pass filter

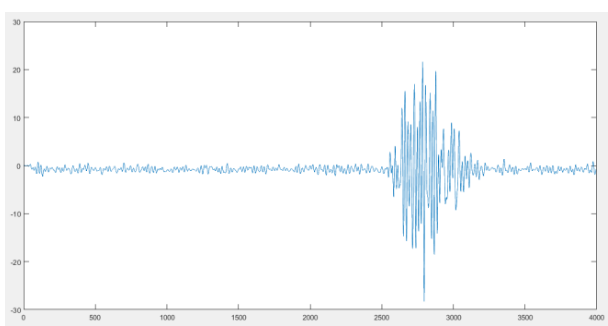
This same signal is passed by the filters Wavelet Syms family as mentioned above are widely used for filtering of such signals. For this application the function DWT (Discrete Wavelet Transform) for its acronym in English is written. These wavelets are compact support, less asymmetry and regularity, ie a reconstructed signal smoothly.

d = dwt (signal, 'sym1')

As the final results of the comparison of these filters with physical filtration to validate be presented in the next section.

Results

In this section the results of the above three steps are presented. Applying low pass filters and high pass result can be seen in Figures 4 and 5. It is clearly seen that the low pass is less concentrated as it eliminates those high frequencies according to the filter characteristics of Figure 2.



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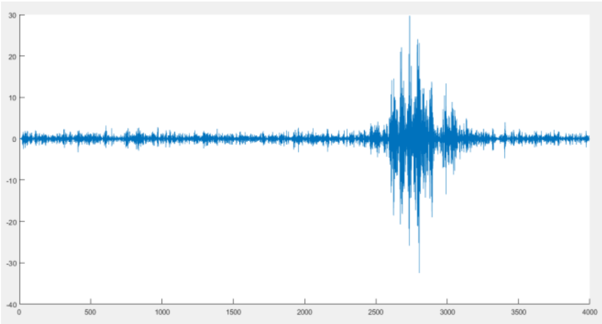

Figure 4 resulting signal after lowpass filter (top) and high pass (bottom)

In addition you can see the result of comparing these two graphs. The comparison between the signals lowpass and highpass shown in Figure 6 which shows that effectively when the high pass filtered, the concentration signal is denser.

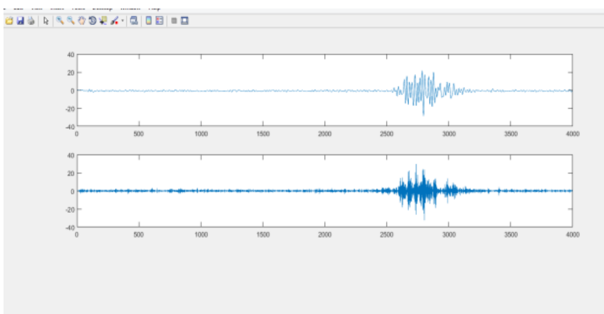

Figure 6 Comparison between the lowpass filter and highpass

When applying low pass filters and high pass, we see some signs of removing trivial to study the desired signal frequencies, as was done physically in the signal acquisition to make the comparison then develops. Then the result of applying a filter Wavelet Sym to the original signal of interest is shown. As seen in the image these filters have a shift to the left, avoiding further prevents further processing.

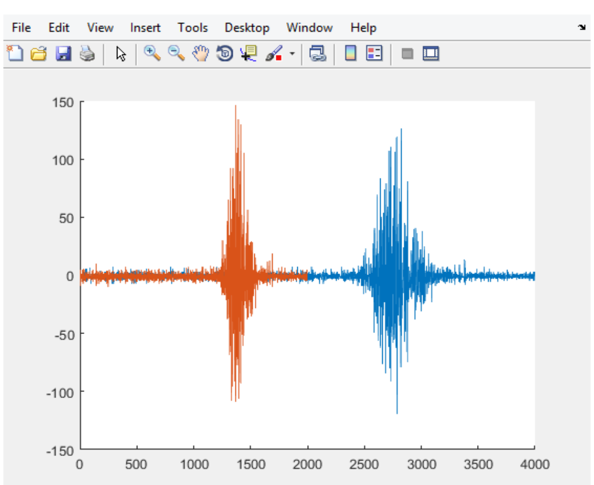

Figure 7 Comparison between Wavelet and applying the original signal

It is noteworthy that in applying this filter finer results and noise removal is obtained is made more faithfully. Plus it allows us, in a post-filtering process, controlling the main component for use in any application or future work.

The following figure shows the result of the first step of the signal acquisition for analysis (above Wavelet filter, filtering down physical). One can also observe the smoothing signal with the physical filter applied to the signal where commercial components which similarity results are shown as those obtained with the wavelet filter in Matlab were used. Physical stage uses conventional filter for external noise capacitors 2uF causing some low amplitude oscillations in the graph.

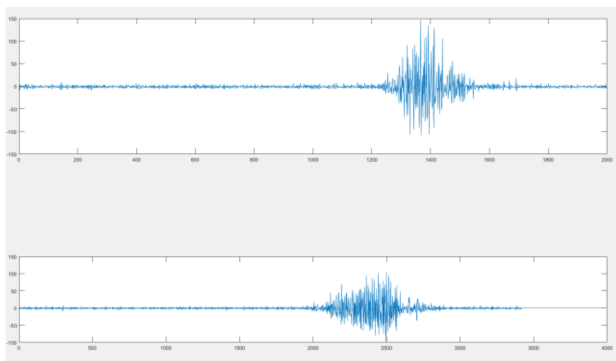

Figure 8 Comparison between Wavelet and applying physical filter

Annexes

generic code used

```
close all
clear all
senal=xlsread('Ejercicio.xlsx');
s = designfilt('lowpassfir', 'PassbandFrequency', 50, 'StopbandFrequency', 70, 'PassbandRipple', 1, 'StopbandAttenuation', 60, 'SampleRate', 500);
hold on
x=rand(100,1);
y=filter(s,senal);
d = dwt(senal,'sym1');
d2= dwt(senal,'sym20');
d15= dwt(senal,'sym15');
subplot(3,1,1),plot(senal)
subplot(3,1,2),plot(d2)
subplot(3,1,3),plot(d15)
```

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Conclusions

The filter wavelet family removes both high and low frequencies has the advantage that by applying transformed into the time domain and frequency in tandem, softens more accurately and linear any presence of noise more accurately because it of such signals.

It can be seen that compared to the physical filtering software filters have enough similarity therefore can corroborate its validity and the results at a later stage of analysis are good utility for use in any application.

Now that it has been validated by the results of the software, the possibility of applying the signal acquisition and filtering stages and subsequent applications will be taken such as those already mentioned at the beginning of this article.

References

Farrell, T. R., & Weir, R. F. (2005). Pilot Comparison of surface vs implanted EMG for multichannel prosthesis control. *Proceedings of IEEE 9th International Conference on Rehabilitation Robotics*, 277–280.

Geethanjali, P., Ray, K. K., & Shanmuganathan, P. V. (2009). Actuation of prosthetic drive using EMG signal. *TENCON 2009 - 2009 IEEE Region 10 Conference,* 1–5. https://doi.org/10.1109/TENCON.2009.5396091

Kobrinsky, A. E. (1960). Bioelectric control of prosthetic devices. *Herald of the Academy of Sciences USSR*, 30 : 58-61.

Litcher, P. A., Lange, E. H., & Hedin, D. S. (2010). Rechargeable Wireless EMG Sensor for Prosthetic Control. *IEEE*, 5074–5076.

POPOV, B. . (1965). THE BIO-ELECTRICALLY CONTROLLED PROSTHESIS. *J Bone Joint Surg Br., Aug 57*, 421–424.

Raurale, S. A. (2014). Acquisition and processing real-time EMG signals for prosthesis active hand movements. *Proceeding of the IEEE International Conference on Green Computing, Communication and Electrical Engineering, ICGCCEE 2014*. https://doi.org/10.1109/ICGCCEE.2014.6922225