

A Comparative Study of EMG and MMG Signals for Practical Applications

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Abstract. Automated Devices focus largely on eliminating grievances faced by physically challenged patients confined to limitations in motion and communication. A control signal is derived from the body as a measure of its amplitude or as the rate of change of its amplitude. These systems typically use one or two myoelectric channels. Continuous muscle contraction has a limiting effect on circulation causing decrease in extracellular pH causing fatigue. The EMG signals are taken from the subject using BIOPAC MP 150 system. The data is logged and stored as a readable file that is later converted into pulses using NI LabVIEW. While it has been noted that Electromyogram (EMG) is one of the most common biosignal used in these automated devices, its acquisition is limited by requirement of an accurate filtering system and the presence of several artifacts during signal acquisition. Mechanomyogram (MMG) signals are low frequency vibrations produced by the muscles around 5-100Hz that can be acquired by a microphone. As there is always a demand for cost effective, simpler and more efficient devices, MMG hardware is preferred over EMG hardware due to the reduction in hardware complexity, usage of gel-less sensors, the inherent absence of 50Hz noise and the lesser effect of attenuation by fatigue. The signal acquired is processed real-time by a LabVIEW virtual program. The signals are then given out as trigger pulses, of a predefined threshold. A comparative study is done between the two systems to document their individual performances.

Keywords: automated devices, volitional control, emg, mmg.

1. Introduction

Electromyography is a discipline that deals with the detection, analysis and use of electrical signal that emanates from skeletal muscles [1]. The EMG signal is the electrical manifestation of the neuromuscular activation associated with the contacting muscles [2]. The signal represents the current generated by the ionic flow across the muscle fibers which propagates through the intervening tissues to reach the detection surface of the electrode located in the environment ([3], [4], [5]).

The unprocessed signal has amplitude of 0-6 mV and a frequency of 10-500 Hz. The peak to peak amplitude is measured in mV. It represents the amount of muscle energy measured. The range of frequencies is given as for slow twitch motor units (tonic - Type I) 70 - 125 Hz and for fast twitch motor units (phasic - Type II), 126 - 250 Hz.

The lack of proper description of the EMG signal is probably the greatest single factor that has hampered the development of electromyography in to a precise discipline [6]. The EMG signal is acquired from the body using electrodes which may include 50Hz noise due to power line interference. Though, there is no proper filter for separating EMG, its use in devices is many. Its frequency range varies over different sources on the body. Face muscles can emit frequencies up to 500 Hz and heart rate artifact can be eliminated with low end cutoffs of 100 Hz. EMG based motion systems [7] require a lot of filtering hardware and classification algorithm.

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The graph shown below shows the EMG signal acquired from an average healthy subject using BIOPAC. The electrodes are placed on the arm and the subject is asked to flex their arms. It is seen that the amplitude of the signal is less than 0.8V.

Mechanomyogram (MMG) is generated from gross lateral movement of the muscle at the initiation of a contraction, smaller subsequent lateral oscillations at the resonant frequency of the muscle, and dimensional changes of active muscle fibres [8][9]. The MMG signal is a compound signal in which active muscle fibre twitches may be summated linearly or non-linearly. MMG is typically measured by contact microphones or accelerometers on the skin overlying the muscle being monitored. As the mechanical counterpart to EMG, MMG has been used to study muscle pain, muscle fatigue and pediatric muscle disease. MMG is recently being investigated as a control signal for upper-limb prostheses, and alternative access technologies.

MMG are low frequency vibrations of 5-100Hz [10]. The prototype microphone sensor consists of a microphone, microphone preamplifier, low pass Butterworth hardware filter, data acquisition hardware and accompanying data acquisition software. Microphone offers a larger range of usage. It is simple to place and easy to acquire signals. MMG does not have any 50Hz power-line interference as compared to other major signals especially EMG. It also has a higher signal-to-noise ratio than surface EMG and can be used to monitor muscle activity [11] from deeper muscles without the need of needle electrodes that are sometimes required in EMG signal acquisition. When compared with EMG, MMG has great advantage in using it as a control signal for assist devices. Both the signals are converted into a pulse waveform by using almost the same algorithm.

LabVIEW is a platform and development environment for visual programming created by National Instruments [10]. The purpose of such programming is automating the usage of processing and measuring equipment in any laboratory setup. LabVIEW programs are called virtual instruments (VIs). Each VI has a block diagram and a front panel. Graphical approach allows building programs by dragging and dropping virtual representations of lab equipment. LabVIEW is commonly used for data acquisition.

2. Methodology

2.1 EMG acquisition and processing

Four subjects are chosen for the test. The BIOPAC system is connected to the PC through Ethernet cables. The subject is has pre gelled surface electrodes attached on the right arm. The ground electrode is placed on the left index finger for effective grounding. This electrode completes the circuit. Leads from the electrode will be taken to the BIOPAC MP150 hardware. The acquired EMG signals are stored in excel and text formats to be read in future. The signal acquisition was done for 10 seconds with a sampling rate of 1 KHz (1000 Hz). Each recording has 10,000 samples. The uniform number of samples in the recorded data ensures that data from all trials could be processed using the same processing techniques. The final output is a pulsed signal where each pulse corresponds to muscle contraction.

The Acquisition software is run from desktop. The system is properly connected if noise signal appears on the screen. The parameter's values are set as x-axis 0.8 mV and y-axis as 5 sec. The subject is asked to flex and extend his arms in a periodic fashion and the EMG is continuously recorded. The screen shows a pulsed waveform as shown in results. The FFT spectrum of the signals acquired is plotted and studied.

The entire signal processing is performed using NI LabVIEW 8.0. The acquired EMG signals have to be cleared from 50 Hz power-line interference using a Notch filter which eliminates 50 Hz frequency component. After notch-filtering, the signal is rectified to remove the negative components of the signal by squaring. The amplitude also gets squared in this step. A constant value is multiplied to the signal boosting the amplitude of the entire signal by that value. The contraction phase of the signal is extracted from the signal by passing through a low-pass filter which detects only the envelope of the signal. Moving average filter is applied with a half-width of 50. The result of smoothing is a signal with blunt peaks exactly at the contraction phases. The acquired EMG signal has baseline drift which is eliminated by subtracting the drift value directly from the signal. The signal is converted into a pulsed signal using a thresholding block. The result after thresholding is a pulsed signal with amplitude of the pulse at 1V. Next, we amplify the voltage from 1V to 5V. The final output is a pulsed signal where each pulse corresponds to muscle contraction.

2.2 MMG acquisition and processing

MMG can be extracted anywhere near an excited voluntary muscle from the skin surface. The system described is used to acquire MMG from the forearm and process it using NI LabVIEW to form pulses that is compared with EMG signals acquired.

MMG is measured using a microphone sensor. One sensor is placed on the bicep of each arm. The subject is asked to squeeze a squeeze ball. This generates vibrations over the skin that can be picked up as MMG signals. As the muscle at the site of interest is contracted or relaxed, the diaphragm vibrates in resonance with the vibrations on the skin and carries the signal through leads. The acquired signal is passed through an MMG amplifier circuit. This amplifier is similar in design to an audio amplifier. The amplified signal is sent to an NI USB-DAQ, which is uploaded to a system.

A LabVIEW program receives this signal and performs real-time data acquisition, contraction detection and pulse wave modulation. Microphone-detected MMG signals are continuously sampled at 1 KHz. A virtual LabVIEW block diagram that has a DAQ of sampling frequency 3 kHz is created in order to receive the digital sampled signal from NI ELVIS. A rectifier is placed after the DAQ block in order to retrieve only the positive portions of the signal. In order to remove noise a smoothing filter block set at sampling of 21 points is placed. A thresholding filter block with a threshold of 4V is placed followed by graph Indicators with number of samples at 1k.

3. Results

The LabVIEW front panel output is shown

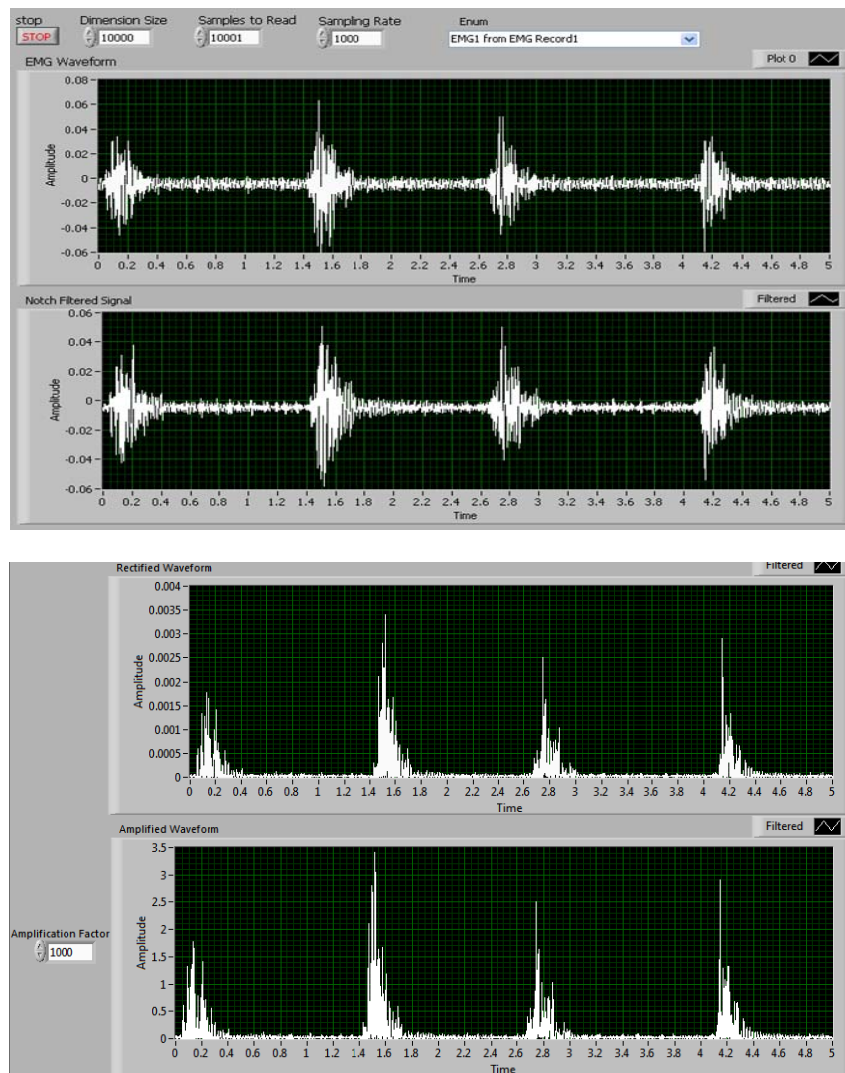


Fig. 1. Acquired EMG signal and notch-filtered signal

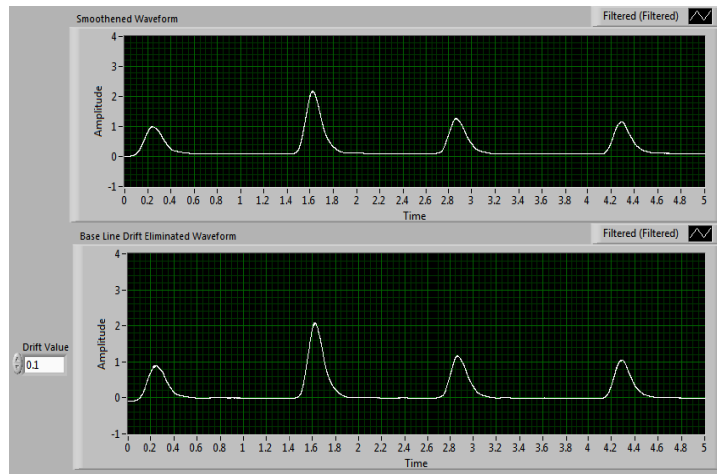


Fig. 2. Smoothened signal and baseline drift elimination

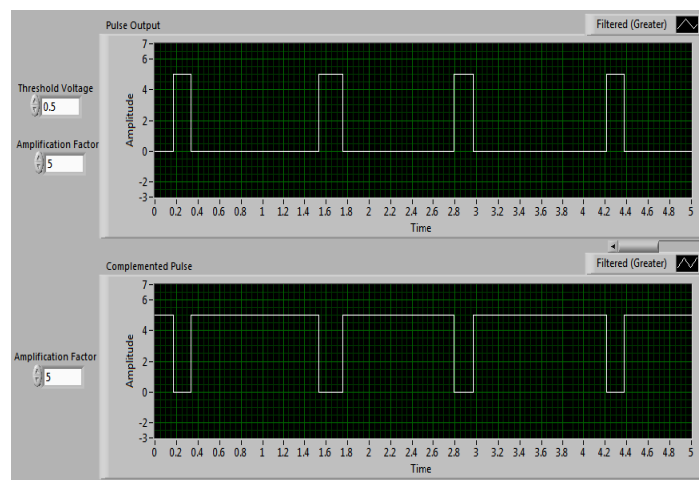


Fig. 3. 5V Pulse output and its complemented signal MMG

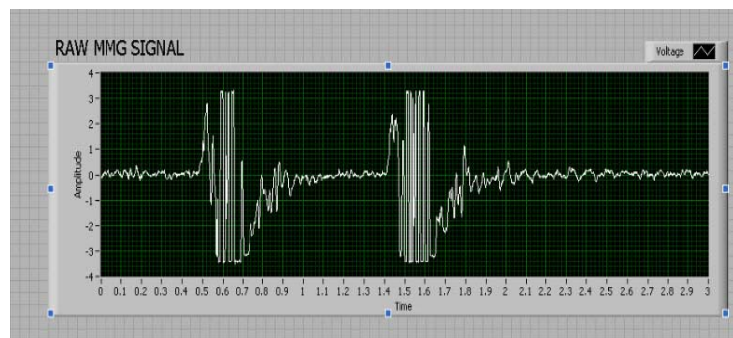


Fig. 4. Signal as obtained from arm.

4. Conclusion and Discussion

The study of individual signal acquisition and processing is done using EMG and MMG signals respectively. A comparative study is also done between the two experiments in order to test the performance of each with a myoprosthetic arm.

It is seen that EMG signal acquisition and processing offers a lot of hindrance and external errors. The difficulty is higher when we consider online or real time processing. The human arm has multiple degrees of freedom. This necessitates the need for more number of motors and respectively more number of EMG signal sources introducing more complexities and errors in signal processing. MMG acquisition has better advantages over EMG from the acquisition and processing stage. The hardware is reduced to fewer and more

reliable measuring devices that increase the accuracy of the system. Muscle sounds can be measured by low cost microphones without the need for fitting an electrode. Microphones are less sensitive to motion artefact and is preferred for detecting MMG as the muscle site is prone to movement. This in case of EMG requires extra motion detection filters in order to separate signal from artefacts. False detection of unwanted contractions can be overcome by increasing the thresholds and analysing the high frequency signal. The signal is less susceptible to electrical interference as compared to EMG as MMG is a mechanical signal and not an electrical signal. This necessitates the requirement of a simple sound shield and removes the need for a notch filter to remove power line interference.

The signals can be processed by ubiquitous and cheap digital audio hardware like DSPs. The signal received is well in the audio range and doesn't need much amplification circuitry for the user to read the signal. Gel-less sensors are used making user more comfortable.

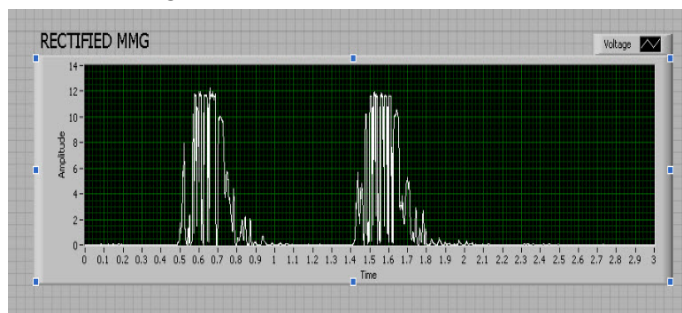


Fig. 5. Signal after rectification.

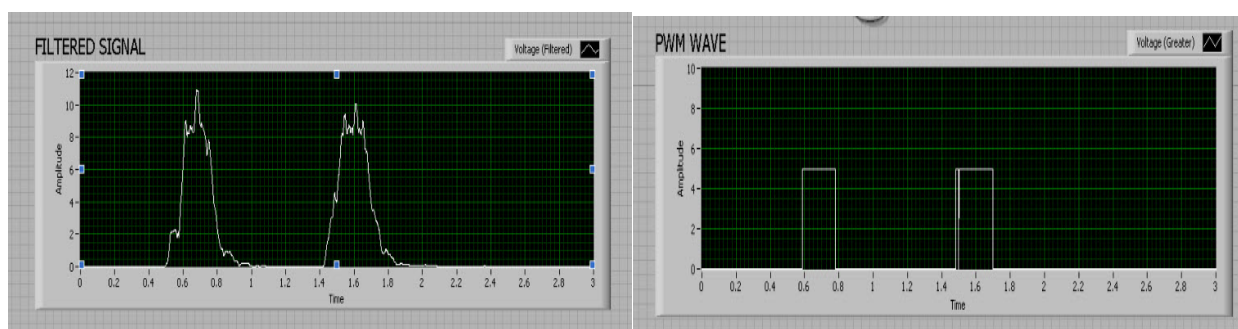


Fig. 6. Signal after smoothing

Fig. 7. Trigger Pulse.

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