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Pattern Behavior of Electromyography Signal During Arm Movements

[1]Zunaidi, I., [1]Wan Zulkarnain, [1]Tarmizi I. and [2]Shahriman, A.B.

[1]*TATI University College, TATIUC Campus, 24000 Kemaman, Terengganu, Malaysia.*
[2]*School of Mechatronics Engineering, Universiti Malaysia Perlis, 02600 Jejawi, Perlis, Malaysia.*

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ABSTRACT

Electromyography (EMG) is widely used throughout the world for different study such as clinical diagnosis and for movement analysis. This paper presents the pattern behavior of recorded EMG signal from biceps and triceps during arm movements. The main point here is that muscle will elicit the signal when performed contraction. Based on the fact that each muscle is responsible for the certain movement, experiments were carried out to observe the pattern of the signal. A subject was asked to perform flexion and extension with different speeds and strength. The signal was recorded using complete EMG system and analyze with EMG Work Software. Our final objective is to develop the Myoelectric Prosthesis Arm using the applications of EMGs. It is intended by all the biomechanics engineer in order to provide better living to the amputees since the current prosthesis are limited.

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INTRODUCTION

The conventional method to study the muscle activity is called the electromyography (EMG) (De Luca, C.J., 2006; Soderberg, G.L., 2000). The EMG is implementing to registration the activity pattern and work load in the muscle. The Electromyogram (EMG signal) has become an important control input because it has advantages compare to the others (Su, Y., 2005; Reaz, I., 2005; Parker, P., 2006). Moreover, the signal generate from the muscles contraction always provide the best for real condition. The method may be utilized to control an artificial arm (Escudero, Z., 1999) whereby one or more sets of electrodes is/are placed to the following muscles: biceps brachii and triceps brachii (Figure 1). This may provide at least two different movements of the artificial arm or part/parts thereof, for example raising the arm in front (flexion) and raising the arm in back (extension). Hereby, EMG signals from different parts of the muscle may be picked up. These EMG signals may differ and may be used to achieve greater reliability and/or even more complex and detailed patterns of movements performed by prosthesis such as an artificial limb (Mohammadreza, A.O., 2007). Thus, the objective of this paper is to measure the EMG signal from the desired forearm muscle and then to observe and understand the pattern of the recorded signal.

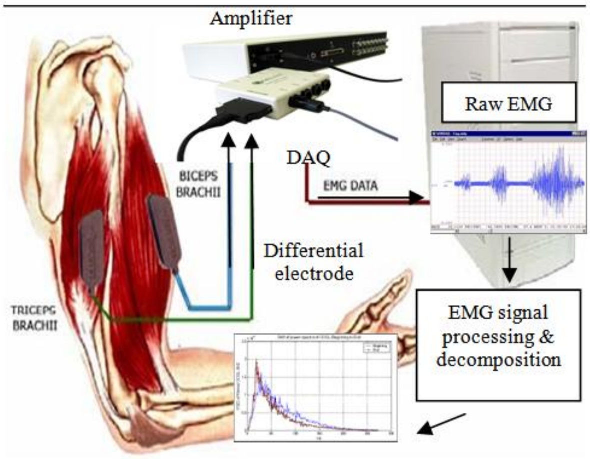

Fig. 1: Basic EMG systems.

Corresponding Author: Zunaidi, I., TATI University College, TATIUC Campus, 24000 Kemaman, Terengganu, Malaysia.

2. Methodology:

This paper will include examination and analysis of preliminary data collected from forearms subject. One healthy subject (with no known Neuro-Musculo-Skeletal) participated in one experimental session. Two EMG electrodes were applied to their left arm. The skin above the investigated (biceps and triceps) muscles was cleaned with an alcohol wipe. Electrical muscle activity was recorded using complete EMG systems as mention in flow diagram of proposed work (**Figure 2**) (Zunaidi, I., 2008). An array of two EMG electrode-amplifiers was secured over each of the biceps and triceps muscles (**Figure 3**).

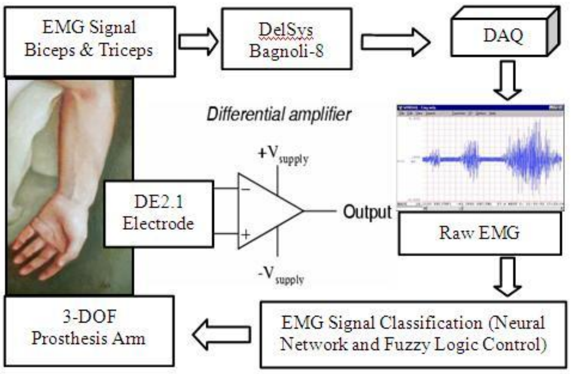

Fig. 2: Proposed Flow diagram.

The surface electromyographic (sEMG) signal was recorded from the muscle using a bipolar surface electrode (DE-2.1, Delsys Inc., Boston, MA). The electrode was placed on the distal third of the biceps belly, away from the motor point towards the distal tendon. Another electrode was placed between the distal tendon and the top of the belly of the triceps brachii lateral head to monitor activity in the antagonist muscle. An adhesive ground electrode was also secured over the clavicle. The EMG system (Bagnoli 8, Delsys Inc., Boston, MA) further amplified the signals (1000×) before they were band-passed filtered (20–450 Hz). All signals were sent to a 16-bit A/D converter (NI USB-6251, National Instruments).

After electrode placement, data were collected during 4 motion classes depending on strength (weak, strong contraction) and speed of forearm flexion and extension. The subjects were instructed to start from rest, elicit a required force isometric contraction for 5 s and then return to rest. Ten repetitions were collected for each motion, corresponding to 50 s of active data for each motion class.

Fig. 3: Performed flexion-extension.

Table 1: List of forearm muscles, arm movements, speed and level of contractions involved.

Muscle	Movement	Speed and strength of contraction
Biceps vs Triceps	Flexion-Extension	Slow-Strong (SS)
Biceps vs Triceps	Flexion-Extension	Slow-Weak (SW)
Biceps vs Triceps	Flexion-Extension	Fast-Strong (FS)
Biceps vs Triceps	Flexion-Extension	Fast-Weak (FW)
All muscle	No movement	Normal (N)

3. Experimental Results:

3.1 EMG signal:

Figure 4 shows the raw EMG signal recorded from forearm surface. The signal was acquired from contractions of the biceps brachii muscle and triceps brachii. When a muscle is relaxed, a more or less or 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. A burst in the recorded signal was observed during muscle contraction. From the obtained graph, an EMG signal of amplitude ±5mV is evoked during muscle contraction.

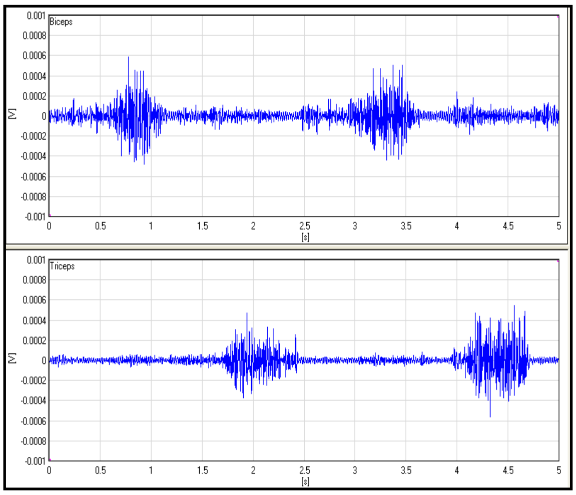

Fig. 4: Flexion and extention of EMG signal; biceps muscle (upper graph) and triceps muscle (lower graph).

The experimental results also show that electrode placement with respect to the desired muscles also reflect the accuracy of the signal (Figure 5). The figure show that both muscles contracted at the same time revealed that the second sensor was not placed correctly on the triceps belly. Despite, it was placed over the same biceps muscle but in different location. The figure displays the reduction in the peak height in the lower graph. In this case the location of channel 1 (upper graph) was selected as the best signal with high burst of amplitude.

It is also showed that speed and strength of motion also produced different pattern behavior of the recorded signal. With fast flexion, the initial EMG was characterized by a triphasic pattern with three burst of activity in both muscles and only two burst of signal (varied in timing). Figure 5 also display the EMG signal of strong and weak contraction, which is showed that height of amplitude varied in the overall activity of the EMG signal. The results obtained proposed that strength of motion (strong and weak) data need to be further investigating for control source.

3.2 Co-activation of Adjacent Muscles:

In the recorded signal, there was observed the co-activation pattern between two muscles involve (Figure 6). When the biceps muscle is activated forcefully, it causes a minor increase in the activity of the triceps. Likewise, there is a minor increase of activity in the biceps trace when the triceps is activated. For each strong contraction, the biceps muscles elicit in a range of ± 10 mV and triceps elicit ± 9 mV. From the obtained graph for weak contraction of biceps activity is in a range of ± 6 mV and ± 4 mV for triceps.

4. Finding and Discussion:

This experiment was designed so that it will show the different pattern behavior of arm movements. Firstly, the recorded signal is defined as raw EMG signal which is an unfiltered (exception: amplifier band pass) and unprocessed signal detecting the superposed MUAPs (Reaz, I., 2005). However, it was showed that improper placing the sensors will affected the signal. Many recent studies have addressed the importance of using proper electrode placement when recording surface EMG signals (Malek, M.H., 2006; Beck, T.W., 2007; Beck, T.W., 2008).

The raw EMG signal is a complex spiky signal that can be very difficult to interpret. Therefore, a variety of signal processing technique was done to make it easier to read (Parker, P., 2006). From this preliminary data, the major problem found in the recording system and the technique applied. Since, sometimes the noise baseline is high. Therefore several factors need to be taken into consideration in order to acquire better results. The best way is to collect the signal along region halfway between the center of innervations zone and the distal tendon (Nishihara, K., 2008). It is also determined previously that surface electrodes may record from several muscles at the same time (crosstalk), and may move relative to these muscles as the subject performs a task (Zahra, M.K.M., 2000). Crosstalk must be minimized for accurate analysis.

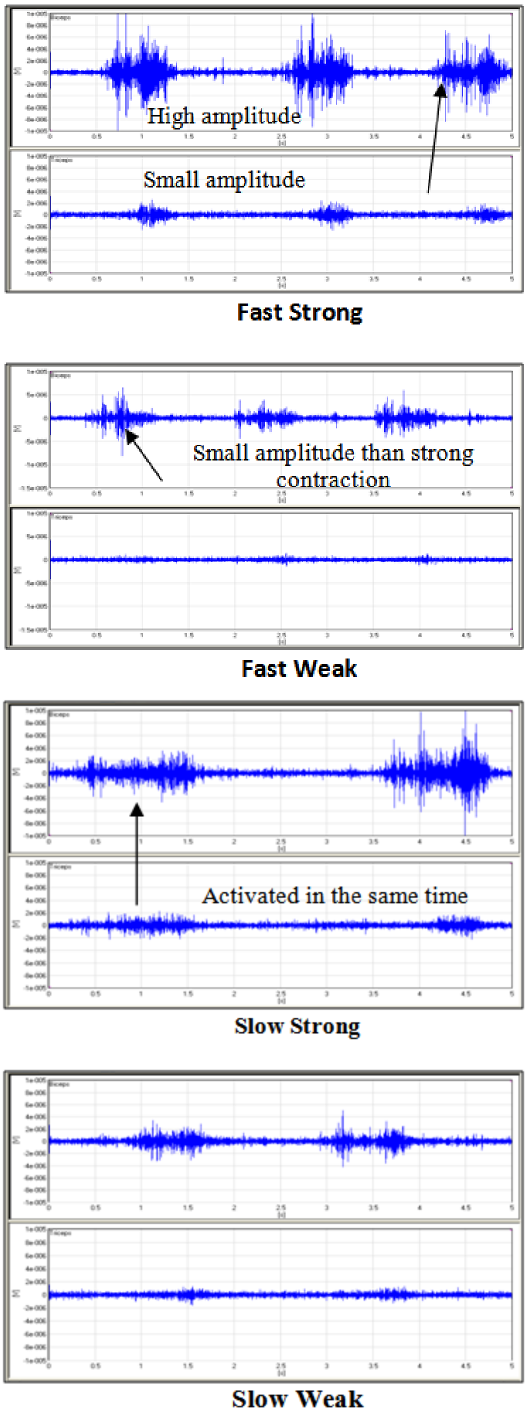

Fig. 5: EMG signal of forearm muscles contraction from two movement variables; speed and level of contraction.

There was also shown the co-activation (cocontraction) pattern of the recorded EMG. The muscle work together and there is a large-scale alteration of activity in the biceps and in the triceps. The co-activation was defined as an area of positive overlap between the agonist and antagonist muscles from the onset of movement up to the end of movement (Zahra, M.K.M., 2000). It is likely that the co-activation of both muscle and combined with crosstalk between signal from adjacent muscle could mislead the results. The above mentioned was found by Ian (Ian, A.F.S., 2002), that both factors could misleading the sensitivity of surface electrode to record the electrical signal of multiple dorsal trunk muscles. It should be noted that the levels of antagonistic activity recorded were probably overestimated because of 'crosstalk' between recording electrodes (De Luca, C.J., 1988; Koh, T.J., 1992; Zhou, B.H., 1996). It is also found that alteration in cocontraction is due to skill acquisition and to maintain joint stiffness. As mentioned early by Kristina and David (2007) that low level of triceps (antagonist) cocontraction is to provide joint stability.

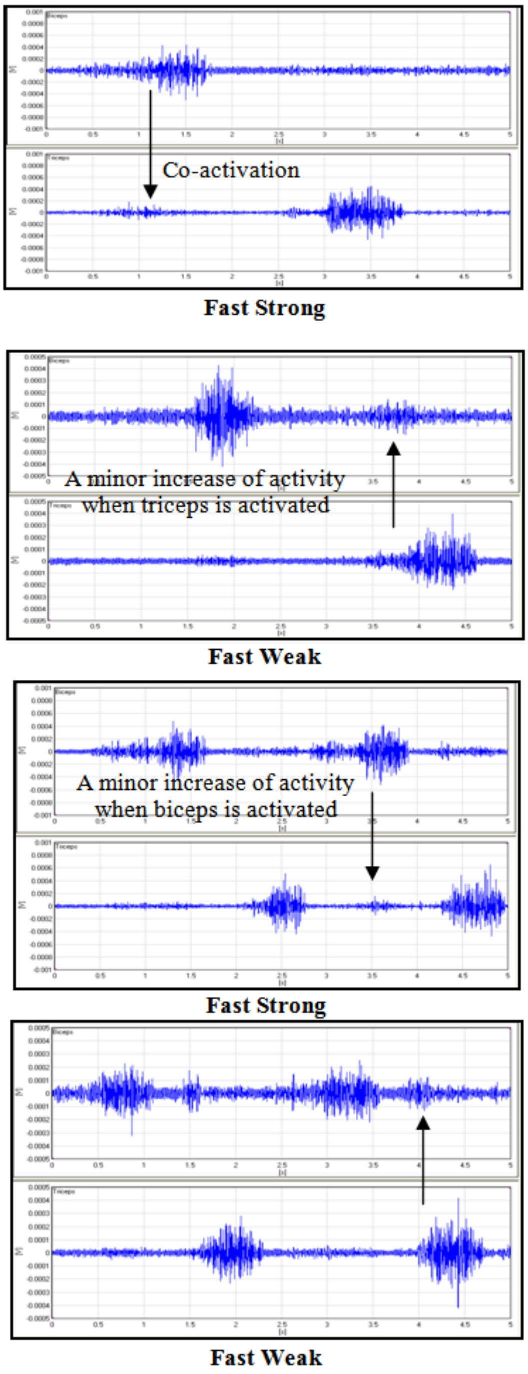

Fig. 6: Co-activation of EMG signal of forearm muscles contraction.

5. Conclusion:

In summary, overall we have successfully recorded the real EMG signal by using the system. Currently, our main target is to collect the signal and to observe the pattern behavior of EMG during arm movements. The raw EMG data is able to show the present the different pattern of certain muscle contraction. However, validation of the signal reliability need to be further investigated since the signal can be affected by crosstalk from adjacent muscle and high contaminant noise.

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