Human Machine Interfaces by Means of Muscle Control

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***Abstract* - This project aims the development of a Human Machine Interface (HMI) muscle control system. The HMI can vary from entertainment to medical purposes, such as slide viewer, browser, music media player or prosthesis. A custom-made hardware was developed to acquire four channels of myoelectric (EMG) signals. Using normalized energy and Kmeans five hand gestures could be recognized on line, with an overall accuracy of more than 90%.**

I. INTRODUCTION

The myoelectric (EMG) signal originates from the central nervous system called motor cortex and it is a voluntary action potential to the muscles. Even though an amputee, who does not have a part of a limb, is able to generate the signal matching to execute a specific movement or gesture. Specialized processing algorithms can recognize special features, which change with the signal, characterizing the movement or the gesture [1, 2]. Thus, a Human Machine Interface (HMI) can be controlled by means of a gesture recognition system, based on EMG analysis.

II. METHODOLOGY

A custom-made hardware was developed to acquire EMG signal. It is battery powered, uses INA121 as instrumentation amplifier with gain 1000, 60 Hz notch filter and 20-500 Hz band pass filter, both made with UF42 Universal Filter. It was used 4-channel-setup-system with surface electrodes, those positioned around the upper extremity of the forearm. The reference electrode was positioned on the olecranon.

The acquisition protocol was applied for five subjects with no physical disabilities. It was used an Arduino Kit programmed in C language with 3000 samples/s, for digitalization and processing signal. Five different gestures were selected among thirteen studied movements, with thirty repetitions for each one, and rest intervals between series.

In order to recognize the hand gestures, the total energy of a one-second period for each channel, during the static phase of the gesture, was calculated, the voltage peak was established, and in addition to that, the energy was normalized by a channel's higher energy in that instant. Kmeans algorithm was used to identify each gesture class [3].

The output control signal uses a Zigbee transmission protocol. Thus, any HMI from 100 meters of distance can be control.

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III. RESULTS AND CONCLUSIONS

The acquisition of the appropriate period of data, their analysis, and the use of normalization of the energy in that period, made possible the identification of 5 hand gestures for each of the five subjects. Table 1 shows very satisfactory individual results, with the overall accuracy higher than 90%.

TABLE 1 – ACCURACY (%) FOR EACH GESTURE MADE BY EACH SUBJECT.

	Subj. 1	Subj. 2	Subj. 3	Subj. 4	Sub. 5
Hand Open	90	88	95	92	90
Wrist Extension	88	80	85	89	94
Wrist Flexion	92	95	92	89	90
Wrist Radial deviation	98	98	97	95	96
Hand Close	95	93	97	98	98
Average	92,6	90,8	93,2	92,6	93,6
Overall	92,56				

This project confirmed that it is possible to control various HMI with only the use of combination of muscle contractions those exist during hand gesture. There was not any other sensor type, such as gyroscopes or accelerometers. In addition, this work suggests that it is possible for a physical disabled person to control a prosthesis, offering a better way of living as long as the person understands that there are some limitations, such as the correct positioning of the electrodes and the needs for training the algorithm with the user's data.

It is important to highlight that, with just five hand gestures, it was possible to open, close, and play videos, games, slides, spreadsheets, those HMIs included in daily activities. Thus, this kind of system can facilitate the life of disabled people. Moreover, it is also important to point out that each gesture are not directly associated to each control signal. It means that, it is possible to make gesture combination sequences and thus, more command signals can be generated.

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