Case Study of an Artificial Hand Control Using EMG Signal and Future Proposal

BOGDAN SOCHIRCA, ROXANA BUBATU
Department of Control Engineering, Computers, Electrical and Power Engineering
University of Petrosani
20 University Street, 332006, Petrosani
ROMANIA
soky_b_2004@yahoo.com, roxana.bubatu@yahoo.com, www.upet.ro

Abstract: - In this paper the case study of an artificial hand control using EMG signal and some proposal was presented. The human is the most complex biological machinery in the world. It is difficult to replicate many functions off the body but with the help of the new sensor, computer and electronics it is possible the use of signal generated by the different parts of the body, in complex machinery in order to control some motion devices. Electrocardiography (ECG), Electromyography (EMG), Magneto encephalography (MEG) or Electronystagmography (ENG) are just some techniques that read human electrical for future developing the model of human internal structure.

Key-Words: - Neuron, brain, EMG signal, microcontroller, motor cortex, programming

1 Introduction

At humans the brain is the superior-most region of the vertebrate central nervous system. At the animals is not the same, the brain is anterior-most region of the vertebrate nervous system. This is the cause that animals rarely assume a biped position. The brain acts in two ways, one is by generating patterns of muscle activity and the other is by releasing chemicals neurotransmitters hormones.

The part of the brain responsible with the execution of the voluntary muscle movement is the sensory motor cortex. In fig 1 it can be observed the way of the signal from motor cortex to muscle. [1]

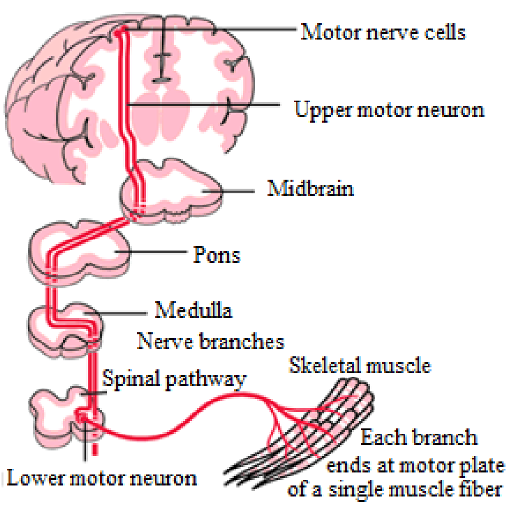

Fig.1 The muscle control from the brain

One of the early studies of motor cortex is since 1970 when Gustav Theodor Fritsch and Eduard Hitzig, applied electricity, with the help of a probe, to a dog brain without anesthesia, discovered that electricity caused involuntary muscle contraction of specific dog body. These experiments took place at the Eduard Hitzig house because the University of Berlin would not allow such experiments in their laboratory.

One of the questions related with the brain that travel along the world and rise up a lot of debate is "How brain communicates, in analog or digital mode". David McCormick, professor in the Department of Neurobiology, said in one of his studies said "*It's as if everyone thought communication in the brain was like a telegraph, but actually it turned out to be more similar to a telephone*". In the brain are more than 100 billion nerve cell, each one can be resembled as a communication device, telephone, and the axons like a communication cable.[4]

2 Problem Formulation

Neurons use neurotransmitters to communicate with each other. They use axons as an output and synapses as an input (fig.2)[3]

Through a synapse, when a neuron receives transmitters, it causes the voltage inside the cell to fluctuate. If the voltage generated is above a certain level, about 80mV, it generate an action that sends a specialized waveform out the axons releasing a transmitter to the other neuron that form the chain, and this one repeat the action to the next neuron, and so on until the power runs out. This type of signal transmitting overturn the belief that signals is sent digitally depending only the rate of transmission and the timing of the action.

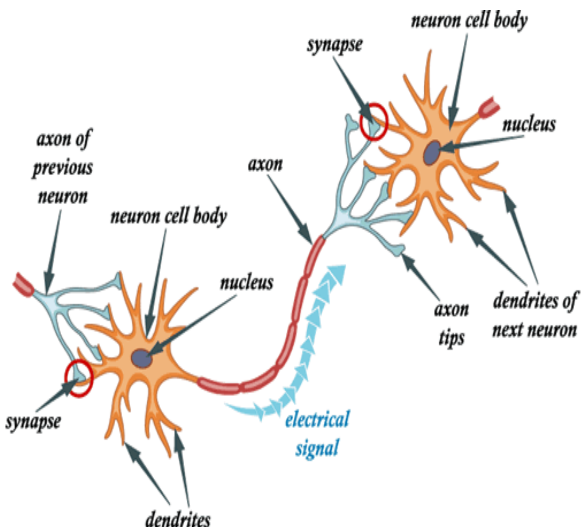

Fig.2 How information traveled through neuron

David McCormick [4] discovered that a certain analog signal is present in each neuron, which combined with the signal received through synapses, modifying the signal transmitted to the next neuron, altering the original signal by each pass through a neuron. The voltage of the sending signal becomes more positive, resulting enhancing of the amplitude of future transmissions. This is part of how is formed the neuron nets and store our experience or human memory.

For recording and evaluating the electric activity of skeletal muscle is used a technique called electromyography. This record is made in two ways: surface or intramuscular. On the first technique the electrodes are placed above the skin, at the second one, one electrode with two this wire is inserted through the skin into the muscle. The EMG signal can be used to control prosthetic devices such hand, arm, lower limbs, etc. These signals are used for creating a human computer interface connecting a human directly to computer. Electrode placement will vary depending of what muscle activity want to be observed.

We want to record the activity of muscle from forearms in order to determine finger movement.

3 Problem Solution

The easiest way is to place 1 electrode of each muscle that involved each finger movement, in total 5 electrodes. In his paper we try to recognize any pattern for each finger movement with the use of only 1 electrode, through the muscle of the forearms.

For EMG detection is used a numbers of electrodes: 3 electrodes, 6 electrodes and 12 electrodes. As many electrodes it is so many signal from different muscle can be acquired. We use 3 leads electrode: left, right and DLR. If we make an analogy with electronic we use positive, negative and ground wire.

The signal from the muscle is acquired and is processed electronic board whose diagram is represented in figure 3 and some software filter it can be achieved an electrical signal that can be traced. For representing the signal obtained we developed a program in Processing, acquisition of date are made through USB port. The whole process is controlled by a microcontroller, a development board (Arduino) based on an Atmega328 microcontroller.

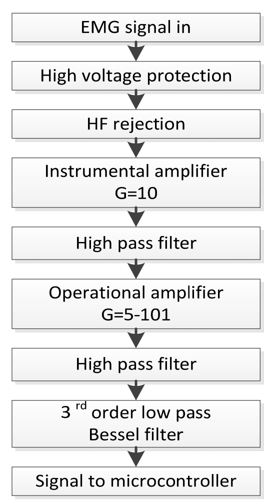

Fig.3. The electronic part structure

After the whole hardware and software data processing, it can be identified, for three of five finger of the hand, a pattern that represent to movement of the finger, from rest to maximum position and back, with no force opposing the movement.

In figure 4 is circled a identified pattern for index finger, in figure 5 is circled for middle finger and in figure 6 is for ring finger. The signal traced in figure 7 and 8 is for each finger moved one by one in a random order.

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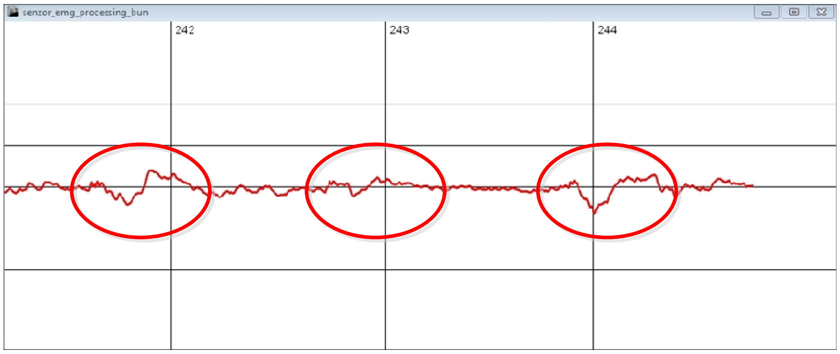

Fig.4. Index finger signal acquired

It can be observed, in figure 4, a very good pattern identification of index finger movement.

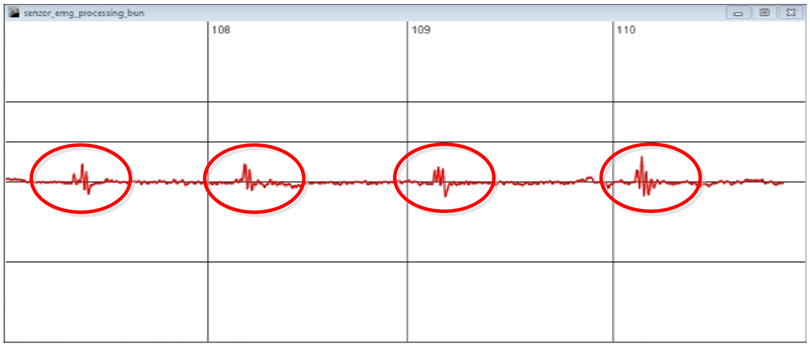

Fig.5 Middle finger signal acquired

Repeating the same procedure, but with middle finger movement, another pattern can be observed for this finger also with very good results in identifying which finger moves.

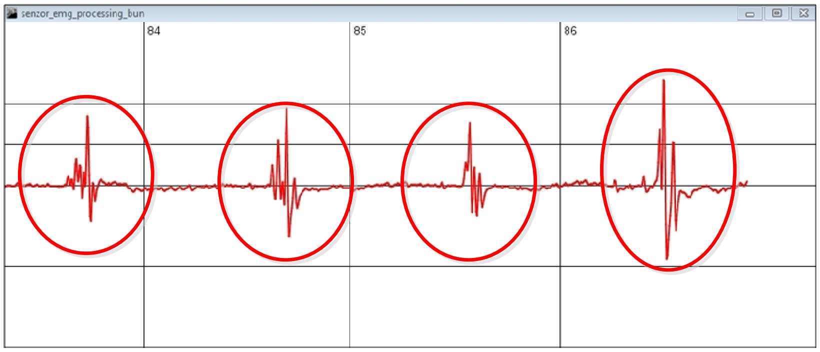

Fig.6. Ring finger signal acquired

The most clear finger movement recognition is for ring finger, which is from far the best pattern obtained.

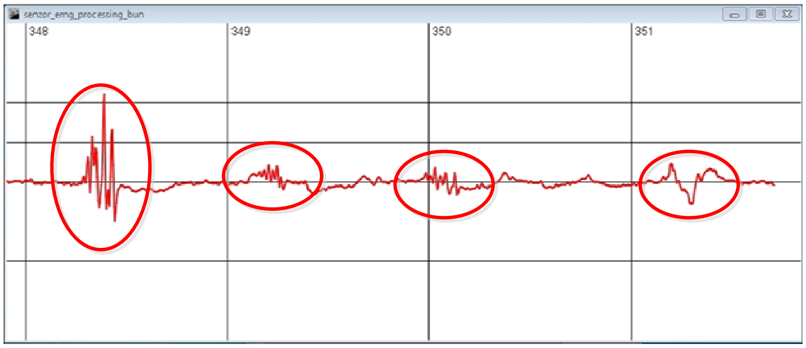

Fig.7. Random fingers movement signal acquired

In figure 7 and figure 8 is a sample for only one at a time finger movement in a random order, with purpose of good pattern disctintion.

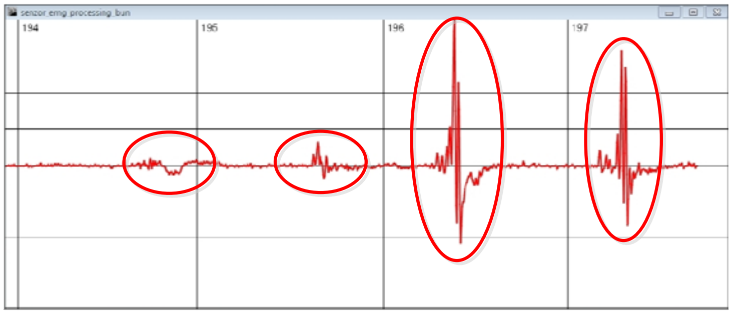

Fig.8. Random fingers movement signal acquired

The idea of the authors is to command an artificial hand (Fig.9) with the aid of a microcontroller and the EMG signal read it from the forearm. First we build an artificial hand with 5 fingers and servos. The artificial hand in this step is controlled with the help of flex sensors.

After we achieved the EMG signals for three fingers future development will integrate those signals in Matlab Simulink for easy filer applying in order to extract a signal for movement that correspond with the forced exercised by the muscle.

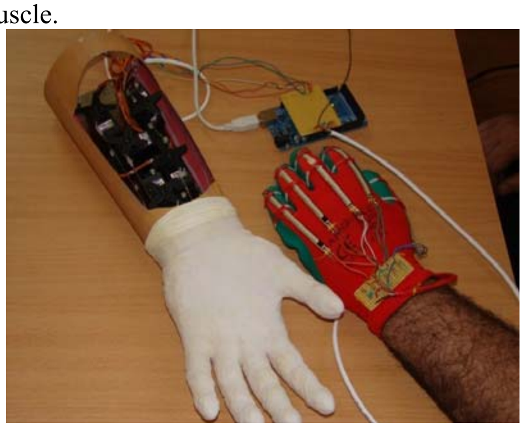

Fig.9. The artificial hand

The results are encouraging fact that makes us to continue to improve the electronics and software.

3 Conclusion

An interface based on EMG signal interpretation can be used for controlling mobile object as robotic arm or for helping people with medical problem. Is no hard way to achieve EMG signal, the difficulty of the problem consist in filtering, interpretation, and integration of these signal in real life application, but can be achieved wonderful and useful application.

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