EMG Pattern Recognition System Based on Neural Networks
@elracional

Abstract

- We present a methodology for movement pattern recognition from arm-forearm myoelectric signals.
- Starting off from the design and implementation of an non invasive electromyography (EMG) instrumentation system.
- Signal processing and characterization techniques were applied using the fast fourier transform (FFT).
- Artificial neural networks (ANN) such as backpropagation and radial basis function (RBF) were used for the pattern recognition or classification of the EMG signals.

Methodology

The objective of our EMG system is to identify a person´s arm movement desired by using two active electrodes placed in the biceps and triceps muscles and another one in the wrist as a reference. The specific movements chosen include the following: the forearm pronation, forearm supination, hand grasp, and the rest state. **Fig. 1** shows the block diagram of the methodology used, and below is a detailed description of each stage. The experiments were performed in 20 persons of different ages.

Stage 1: Electrode Positions

A study of the peripheral nervous system (PNS) and the arm´s muscular system was also carried out. This allowed nine different places to be considered for electrode positioning based on the peripheral nerves: musculocutaneous, median, radial, axillary and cubital as well as the biceps, triceps and brachialis anticus muscles which play a role in the specified movements. **Fig. 2** shows the nine different essential positions for capturing the EMG signals. Electrode A remains in the same position just above of brachialis anticus muscle, while B varies between positions 1 and 8.

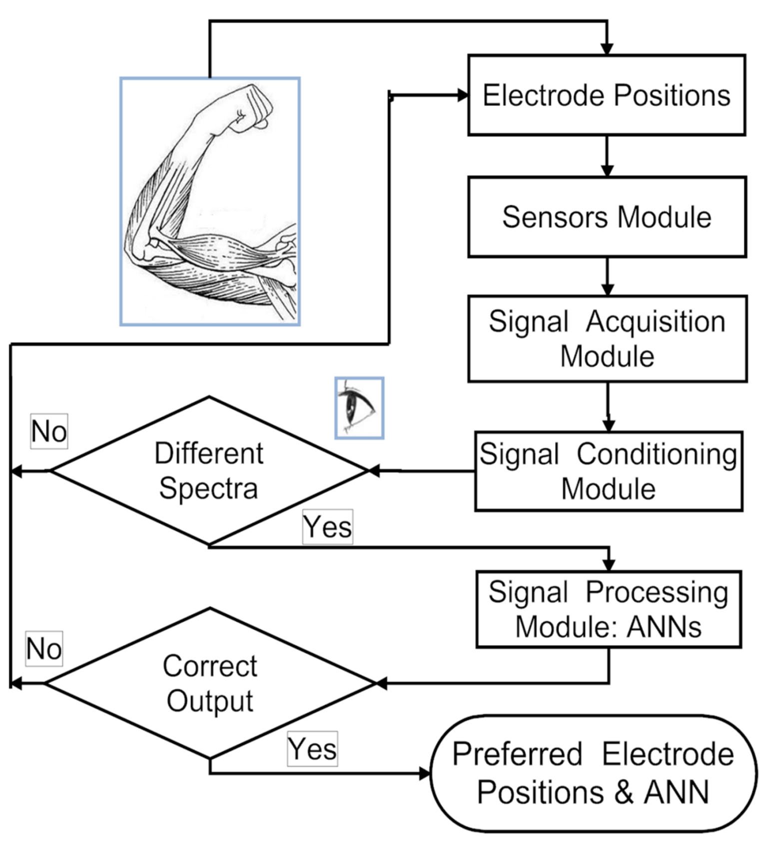


Figure 1. Block diagram of the methodology for the EMG system

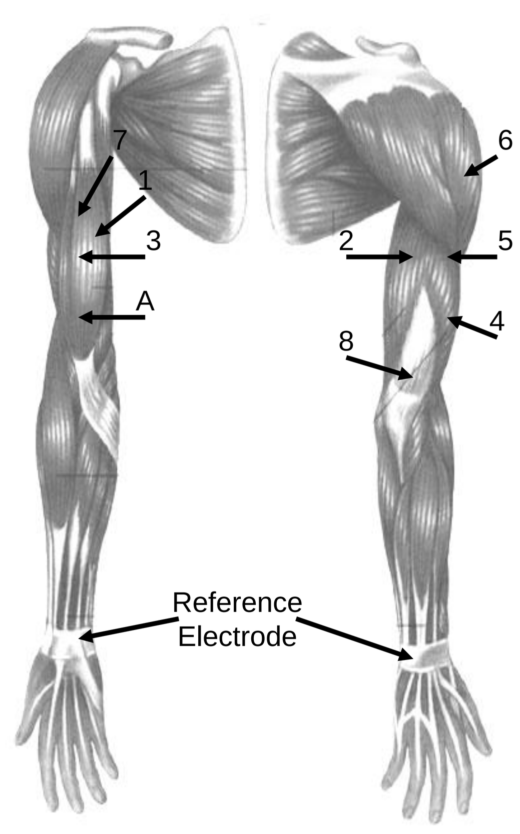


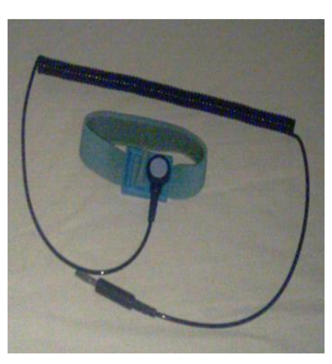
Figure 2. Positions of the electrodes A and B in the biceps and Triceps muscles. Electrode A remains in the same position, while B varies between 1 and 8.

Stage 2: Sensors Module

Electrode B

Electrode A

Bipolar Electrodes



Reference Electrode

Stage 3: Signal Acquisition Module

Electromyograph

NI DAQ-6211

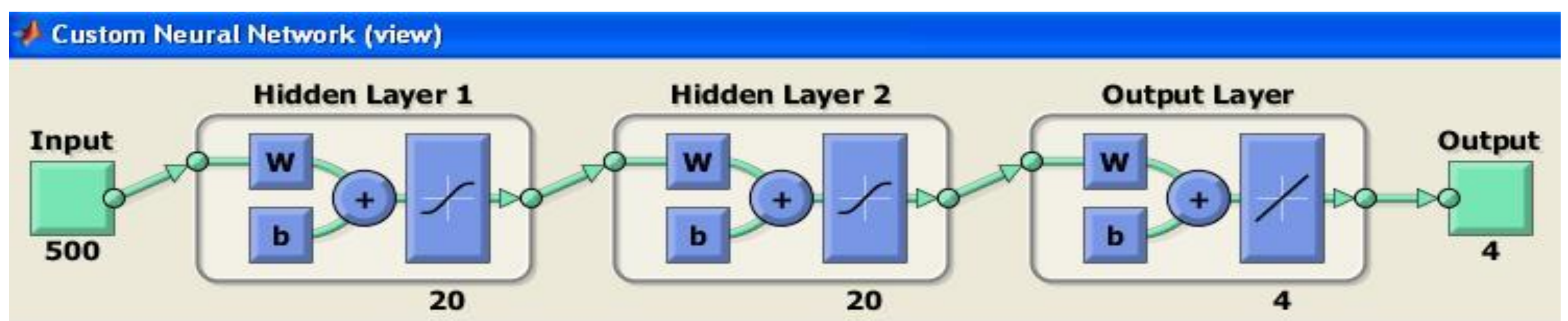
Stage 4: Signal Conditioning Module

Each channel was filtered between 20 and 1000 Hz through a Butterworth pass-band digital filter with a 330 phase gain and a Common-mode rejection radio of 95 dB per channel. The FFT was used during 1 second periods with a sample rate of 10 kHz in order to generate intensity versus frequency spectrums from which the coefficient vector to feed the ANNs was obtained. At this stage, it was decided whether the electrode position was acceptable, or not, by observing the existing relationship between intensity versus frequency spectra of the different types of movements and the rest state.

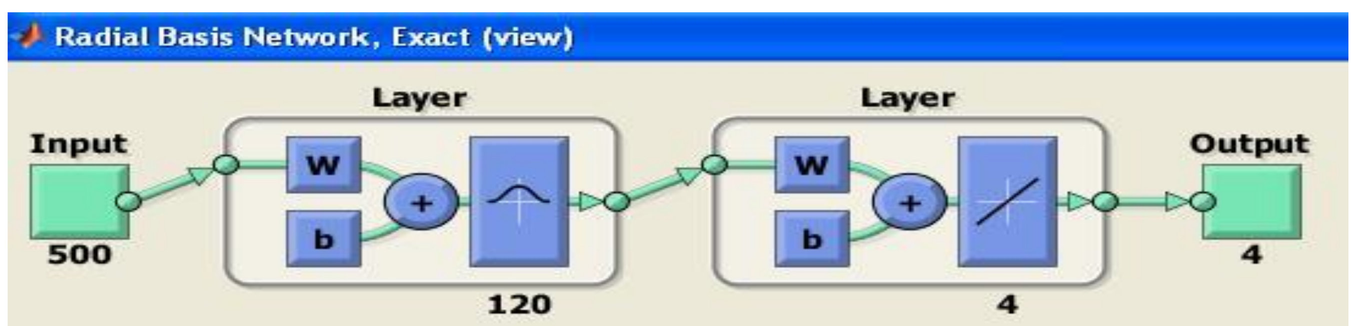
Stage 5: Signal Processing Module

During this stage, the analysis and classification of the EMG patterns through the ANNs was carried out. The data processed by the ANNs are the 800 coefficient vectors (each vector formed by 500 samples), which are formed by the data obtained applying the FFT during one second per each hand movement. The ANN´s output signals are compared to the person´s specific movement, which is made in order to verify that the ANNs are correctly recognizing it; if they do not achieve this, a new position for electrode B was chosen. In assessing the ANNs´ behavior, the following parameters were also taken into consideration: training algorithm, training time, tests, validations, and computer cost.

We used two kinds of ANNs: Feed-forward Backpropagation (BP ANN) and radial basis function (RBF ANN) have been developed in Matlab version 7.

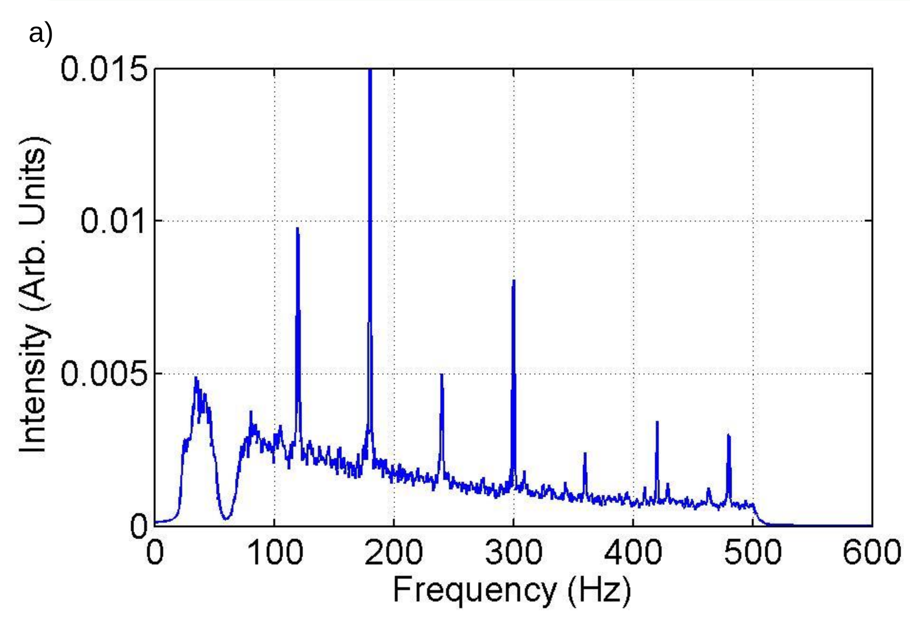


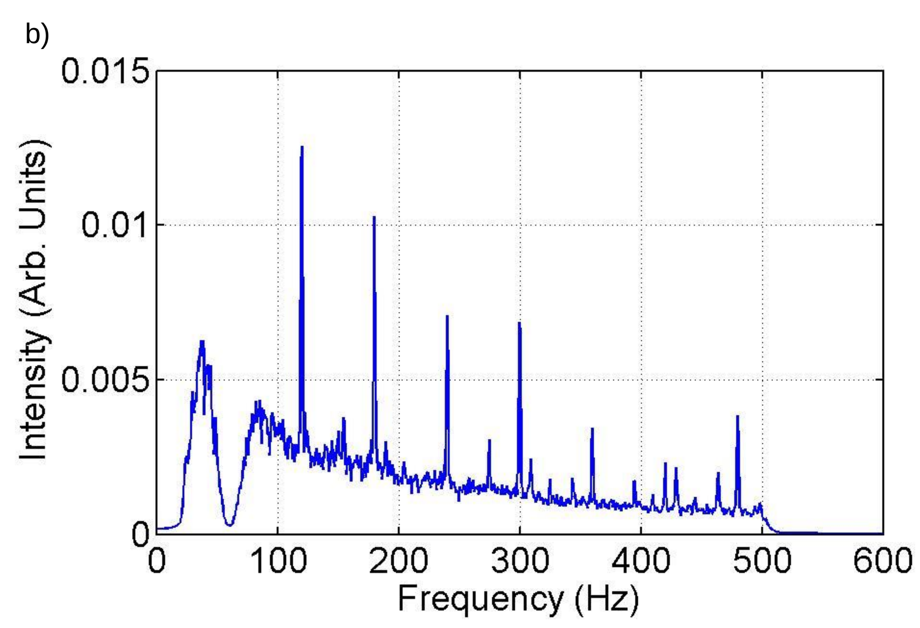
Architecture of BP ANN



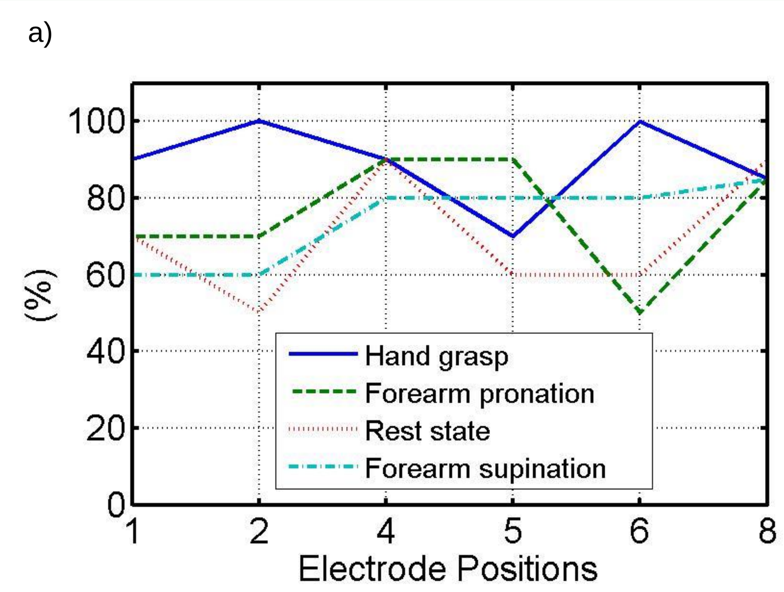
Architecture of RBF ANN

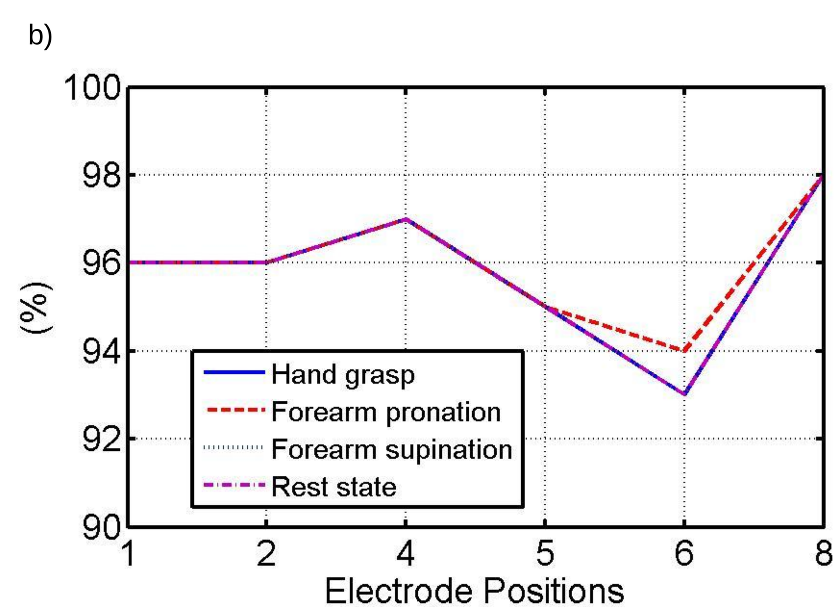
Resultados





(a) Hand grasp and 3(b) forearm pronation movements, show the average of the 20 persons intensity versus frequency spectra, respectively, with the electrode B at position 8.





(a) the BP ANN and (b) the RBF ANN show the average accuracy in the EMG pattern recognition of the three movements and the rest state for the different positions.

Conclusions

✓The selection methodology of electrode positions is an effective technique to optimize an EMG pattern recognition system.

✓Position 8 is ideal for obtaining a high average accuracy in EMG pattern recognition using RBF ANN, with results over 90 %.

✓Recognition times from 1.012 to 2.484 seconds were estimated for the RBF ANN while these ranged from 2 to 10 seconds for BP ANN.

✓The electrode positions near muscular activity and above nerve paths provide more EMG information and notoriously facilitate the EMG pattern recognition.

References

- K. Englehart and B. Hudgins, "A robust, real time control scheme for multifunction myoelectric control," IEEE Trans. Biomed. Eng., vol. 50, no. 7, pp. 848–854, 2003.Inserte aquí cita bibliográfica Inserte aquí cita bibliográfica
- D. Dumitru, A. Gitter "A. Nerve and muscle anatomy and Physiology" Electrodiagnosis Medicine. Philadelphia: Hanley and Belfus; pp. 3–26, 2002.
- Surface Electromiography Non-Invasive Assesment Muscular http://www.seniam.org
- G. Yang, "Study of Emotion Recognition Based on Surface Electromyography and Improved Least Squares Support Vector Machine" J. of computers, vol. 6, 2011.