Description of tissues interaction with a resistive network for the estimation of muscle currents from surface electromyography

Designing and development of better control paradigm for robotic prosthetics are topics that has been increasingly gaining the interesting of the scientific community. Big steps forward has been done from several point of views, from the design of smaller and lighter components to the development of smarter and more accurate control strategies. The most recent control systems, in particular, exploit the neuromuscular information obtained from surface electromyography (sEMG) to interpret the intended movements. At the state of the art the commercially available prosthetics are based on classifiers that trigger a particular movement where a specific sEMG pattern is detected. Direct control of prosthetics still presents reliability issues that preclude its application to a large scale.

We started a study in collaboration with Prof. Piovesan (Gannon University, USA), on a method that exploits the simplicity and linearity of resistive network to model the interaction between the different muscles and tissue identified from a single magnetic resonance imaging (MRI) slice through a segmentation process. This modeling approach aims to overcome the complicated tissue interaction previously described with Finite Elements, reducing the number of interaction modeled to the minimum.

The results obtained from a preliminary application on few isometric contraction of small number of forearm muscles (Fig.1) show that the method is able to correctly estimate the involved muscles and to explain the variance of the input sEMG with a high precision (Fig.2) [1][2]. Further study will be conducted on non-isometric movements involving an increasing number of muscles as well as using time series of sEMG readings to validate its validity for real time estimation of muscle activity.

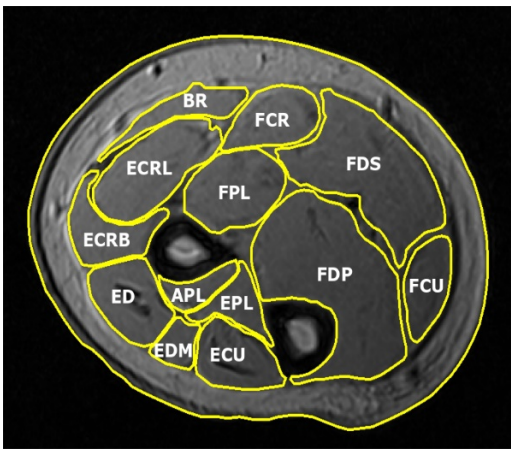

Fig.1 Regions of muscles in a MRI image.

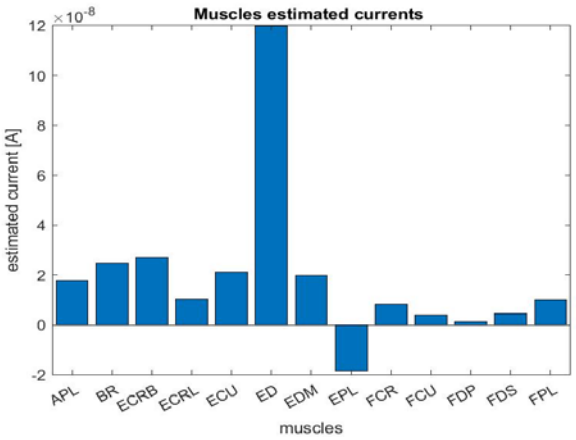

Fig. 2 Estimated current in muscles.

Keywords: Electromyography, Graph Theory, Forearm, Signal Processing, Inverse Problem

References

[1] Piovanelli, E., Piovesan, D., Shirafuji, S., Ota, J., (2019). *"Estimating Deep Muscles Activation from High Density Surface EMG Using Graph Theory"*, IEEE International Conference on Rehabilitation Robotics (ICORR), Toronto, Canada, June 24-28 (2019)

[2] Piovanelli, E., Piovesan, D, Shirafuji, S., Ota, J., (2019). A Simple Method to Estimate Muscle Currents from sEMG using Electrical Network and Graph Theory. Submitted to IEEE International Conference on Engineering in Medicine and Biology (EMBC), Berlin, Germany, July 23-27 (2019), Under revision.