Identification of Non-Propagating Components in Surface EMG Recordings by Optimal Spatial Filtering

T02: EMG signal processing

IDENTIFICATION OF NON-PROPAGATING COMPONENTS IN SURFACE EMG RECORDINGS BY OPTIMAL SPATIAL FILTERING

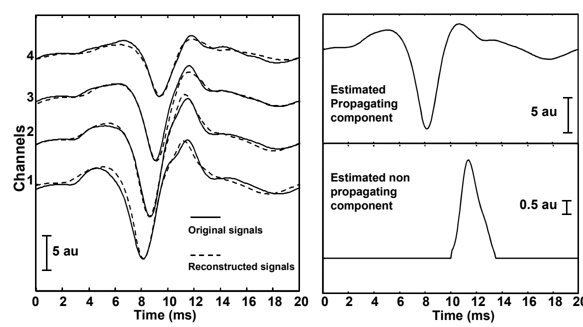
Mesin L.[(1)], *Tizzani F.*[(1)], *Farina D.*[(2)]

[(1)] LISiN, Dept. of Electronics, Politecnico di Torino, Torino, Italy. [(2)] Center for Sensory-Motor Interaction (SMI), Department of Health Science and Technology, Aalborg University, Aalborg, Denmark

AIMS: A new method for the estimation of muscle fibre conduction (CV) from surface EMG signals is proposed, reducing the effect of non-propagating components.

METHODS: Surface EMG signal is modelled as the sum of a propagating and a non-propagating component. The Ppropagating component is assumed to travel without distortion across channels. The Nnon-propagating component is assumed to have the same shape but different amplitudes across channels. Given a pair of spatial filters obtained from 4 detection channels, CV was estimated by the optimal compensation of the spatial filter transfer functions with equivalent temporal filters (with transfer functions of the same shape as the spatial filters) dependent on the delay of propagation to be estimated. Only pair of spatial filters with vanishing weights were considered (resulting to two degrees of freedom). Each filter pair provides a different estimation of the delay, depending on how the non-propagating components are reduced by the spatial filters. The optimal filter pair (to be determined) annihilates the non-propagating components. Imposing this condition, a method to estimate propagating and non-propagating components was developed. The choice of the optimal filter pair was based on the accuracy in reconstructing the input signals by the sum of the estimated propagating and non-propagating components.

RESULTS: The new method was applied to simulated and experimental EMG signals (Figure). Simulated signals were generated by a cylindrical, layered volume conductor model. Experimental signals were recorded from the abductor pollicis brevis with a linear array of 16 electrodes. In the simulations, the proposed approach provided CV estimates with lower bias due to non-propagating signal components than previously proposed methods (simulated value 4 m/s). Restricting CV values to the range 2-8 m/s, mean and standard deviations on a set of simulated signals (3 depths within the muscle, 3 fibre lengths, 10 realisation of 15 dB additive noise) were the following: new method 3.92 ± 0.3 m/s (proposed method); spectral matching method 5.1 ± 1.2 m/s (spectral matching method); reference point (minimum) method 4.4 ± 0.9 m/s (reference points). In the experimental signals, the technique separated propagating and non-propagating signal components with an average reconstruction error of 2.9 ± 0.9% of the signal energy.



EXAMPLE OF APPLICATION OF THE PROPOSED METHOD TO THE SEPARATION OF PROPAGATING AND NON-PROPAGATING COMPONENTS FROM EXPERIMENTAL MONOPOLAR SINGLE MOTOR UNIT RECORDINGS (SIGNALS RECORDER FROM THE ABDUCTOR POLLICIS

CONCLUSIONS: A new method for the CV estimation of conduction velocity is proposed in this study. The technique is applicable to signals with one propagating and one non-propagating component (single motor unit action potentials). The determination of the optimal filters also allows the separation of the propagating and non-propagating signal components. The technique may find application in single motor unit studies for decreasing the variability and bias of CV estimates due to the presence and different weights of non-propagating components.