A NOVEL APPROACH TO VOLUNTARY HD-SEMG DECOMPOSITION

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ABSTRACT

High-density surface electromyography (HD-sEMG) recordings, which employ a grid of multiple densely spaced electrodes over a muscle, can be used to investigate muscle activity in ways that have long been the privilege of needle EMG. One of the openstanding technical challenges is to decompose these recordings into the contributions of individual motor units (MUs). The "signatures" of such MUs on the grid and their firing properties can provide relevant information about muscle (dys)function [1]. Several ways have been proposed to obtain these MU signatures (e.g. [2]), but no optimal method is yet available.

We propose a new and fully automatic approach to this decomposition. We first detect as many shapes as possible that correspond to muscle activity, by determining all threshold crossings on a subset of channels. These channels are selected on the basis of maximal scattering of their positions in the grid. Then, the algorithm employs hierarchical superparamagnetic clustering using the modified Wave_clus algorithm [3] to extract individual shapes. This clustering results in clusters with multiple similar members (which are assumed to represent the repeated firings of a single MU) and in unclustered shapes (which are assumed to represent mixtures, i.e., summed contributions of two or more MUs). Averaging per cluster yields a template of a MU signature. The mixtures are decomposed using these signatures. For this purpose, a set of electrodes is identified that contains the most discriminating information by means of Singular Value Decomposition (SVD) and Generalized Singular Value Decomposition (GSVD) [4]. In order to identify which MUs generate the mixture, we minimize the residue between the mixture and the sum of MUs with respect to the L2 norm on these electrodes. In this way, we can decompose mixtures of up to 3 overlapping MUs reliably.

We verified the algorithm both on simulated spike-train signals and on experimental data. Initial findings are promising, but further validation of the method's performance is required, e.g., with respect to the number of MUs present and their signal-to-noise ratio on the sEMG.

REFERENCES

[1] B.U. Kleine, et al; "Using two-dimensional spatial information in decomposition of surface EMG signals", Journal of Electromyography and Kinesiology 17, pp. 535–548 (2007)

[2] A. Holobar, et al; "Multichannel Blind Source Separation Using Convolution Kernel Compensation", IEEE Trans Sig Proc, Vol. 55, pp. 4487-4496 (2007)

[3] R.Q. Quiroga, et al; "Unsupervised Spike Detection and Sorting with Wavelets and Superparamagnetic Clustering", *Neural Computation* 16, pp. 1661–1687 (2004)

[4] G.H. Golub and C.F. van Loan; Matrix Computations, 3rd edition, Johns Hopkins University Press; ISBN 978-0-8018-5414-9, (1996)