Model selection for the extraction of EMG synergies

Enrico Chiovetto[1], Dominik Endres[1], Andrea d'Avella[2] and Martin A.Giese[1]

1- Section for Computational Sensomotorics, Department of Cognitive Neurology, Hertie Institute for Clinical Brain Research, Centre for Integrative Neuroscience, University Clinic Tübingen, Tübingen, Germany.
2- Laboratory of Neuromotor Physiology, Santa Lucia Foundation, Rome, Italy.

Many recent studies have provided evidence that the electromyographic (EMG) patterns underlying complex movements can be approximated by the combinations of a small number of components, also referred to as muscle synergies. Different definitions of muscle synergies have been given in the literature, which translate into either synchronous or non-instantaneous generative models. However, how to choose a specific model and how to identify its parameters, such as the number of synergies, still remain open questions. In this study, we used Fourier-based Anechoic Demixing Algorithm (FADA), an unsupervised learning algorithm that we recently developed,to address these questions. We first simulated EMG data sets, each one generated according to a well-defined synergistic organization and corrupted with signal-dependent noise. We then used FADA to extract muscle synergies from the simulated data and we applied classical model selection criteria to discriminate the actual synergistic models underlying the ground-truth data sets and to identify the actual number of synergy. We also applied a new objective criterion that we recently developed and which is based on a Laplace approximation (LAP) to the model evidence of a given synergy model. On average, all criteria were capable of identifying to some extent the true generative models underlying the simulated data sets, although LAP was the most accurate in terms of classification performance. Concerning the selection of the number of synergies, LAP performed considerably better than the classical search of an elbow point on the graph of the variance accounted for. Our study contributes notably to the design of useful model selection criteria for the extraction of muscle synergies, in particular for the discrimination between synchronous and non-instantaneous models.

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