THE MODULATION OF MUSCULAR SYNERGIES AS A FUNCTION OF UNEXPECTEDLY PERTURBED GRASPING TASKS

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Introduction

Muscle synergies (MS) are central building blocks for motion production and offer the potential of a more intuitive control compared to conventional pattern recognition methods in upper limb prosthetics since they accompany grasping movements without delay [1]. However, it remains unclear until now to what extent a prosthetic pattern recognition control based on MS is affected by external perturbations.
The aim of the study is to investigate the modulation of a MS model in the presence of external perturbations.

Methods

The activity of 12 arm muscles in 15 healthy volunteers was measured using EMG during object manipulation tasks with and without unexpected weight change. The movements of instrumented grasping objects were tracked using a Vicon optical system. MS were extracted with a non-negative matrix factorization (NNMF) during different grasping phases and grouped with a k-means cluster analysis. Their reconstruction was then performed once with temporal-fixed and once with spatial-fixed synergy components. A significant drop in reconstruction quality would indicate that activation changes cannot be modulated by the respective unfixed component. Wilcoxon signed-rank and rank-sum tests were applied for statistics.

Results

Independent of the motor correction due to external perturbations, the number of recruited MS remained unchanged for each grasping phase. While there was a significant reduction in the reconstruction quality of perturbation-induced muscle activation in temporal-fixed NNMF, this quality remained unchanged in spatial-fixed NNMF. The temporal modulation of subject-invariant MS significantly depended on the context of the perturbation, whereas the MS activation profiles showed a correlation with the object trajectories (Fig. 1).

Discussion

MS appear to be modulated by their temporal rather than their spatial components during perturbations. Thus, modulated MS do not affect the pattern recognition of a prosthetic control and the classification accuracy should not be changed. The context dependence of modulation may find introduction in prosthetics as a complementary control signal to detect the nature of perturbation. It could be used to automatically correct the prosthetic hand (e.g., a follow-up grasp in case of an unexpectedly heavy object).

References

1. Batzianoulis et al. J Neuroeng Rehabil, 26:57, 2018.

Acknowledgements

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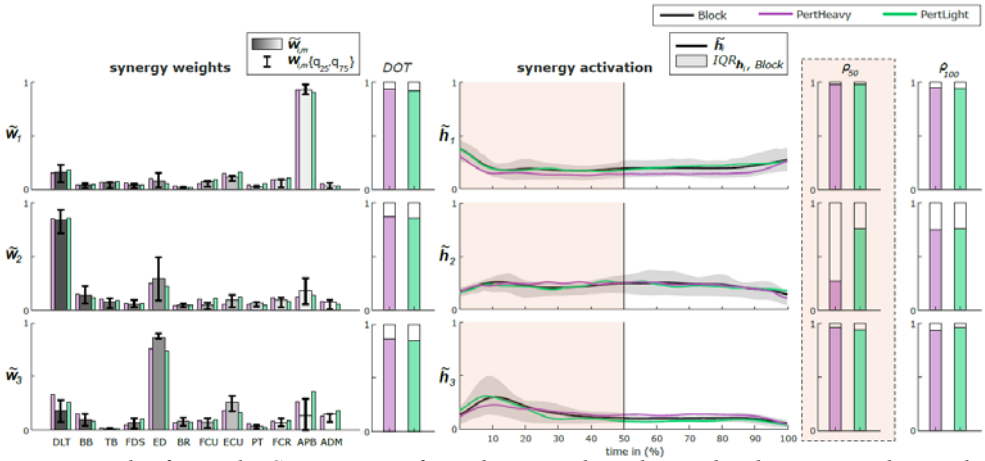

Figure 1: Relative centroids of spatial MS components from cluster analysis during the object manipulation phase (bar graphs, left) and corresponding temporal activations (line graphs, right) for expected (Block, gray), unexpectedly heavy (PertHeavy, purple), and unexpectedly light (PertLight, green) object weights. Spatial (DOT) and temporal (ρ) similarity values are next to the graph; ρ_{50} is the similarity value for the first 50% of the manipulation phase and ρ_{100} covers the entire grasping movement.