EFFECT OF ROBOTIC ASSISTANCE ON THE SYNERGISTIC ORGANIZATION OF REACHING MOVEMENT

Ceroni I.[1,2], Garro F.[1], Semprini M.[1]

[1] Rehab Technologies, Istituto Italiano di Tecnologia, Genova, Italy, [2] Department of Informatics, Bioengineering, Robotics and Systems Engineering, University of Genoa, Genoa, Italy

OBJECTIVE

Quantitatively assess the effect of the assistance of the Float exoskeleton on the modular organization of reaching.

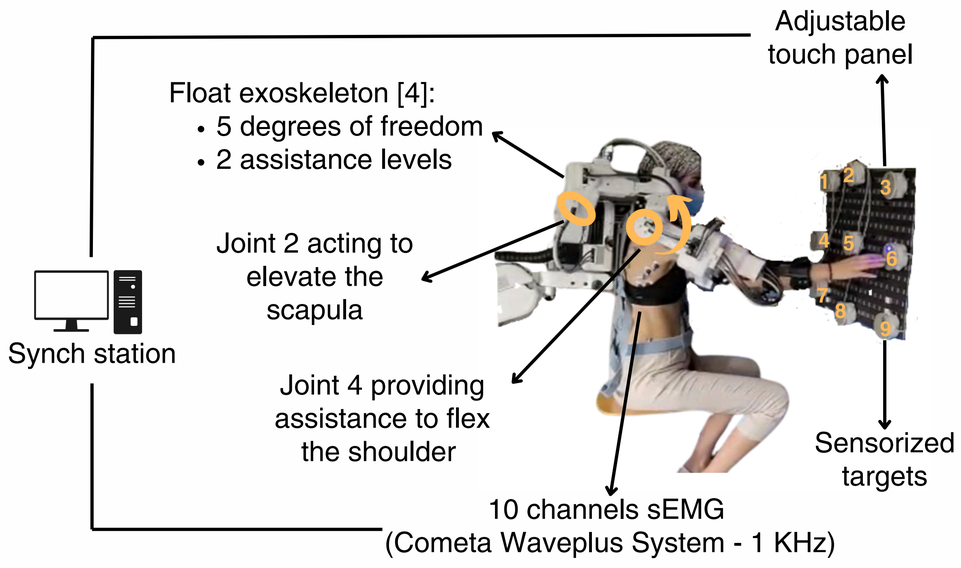
RELEVANCE

Objective characterization of the effects of robotic interventions is still missing [1].

The muscle synergies paradigm [2] can provide a quantitative and objective measurement of the effects of robotic assistance.

A standardized task [3] may enable the comparison among different populations and robotic platforms.

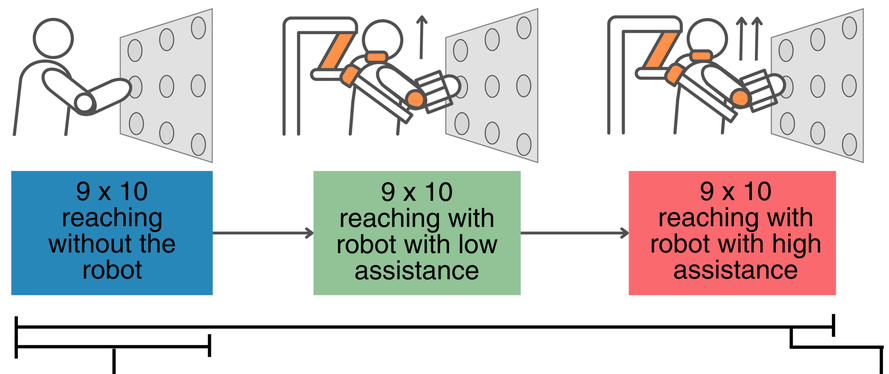
EXPERIMENTAL SET-UP



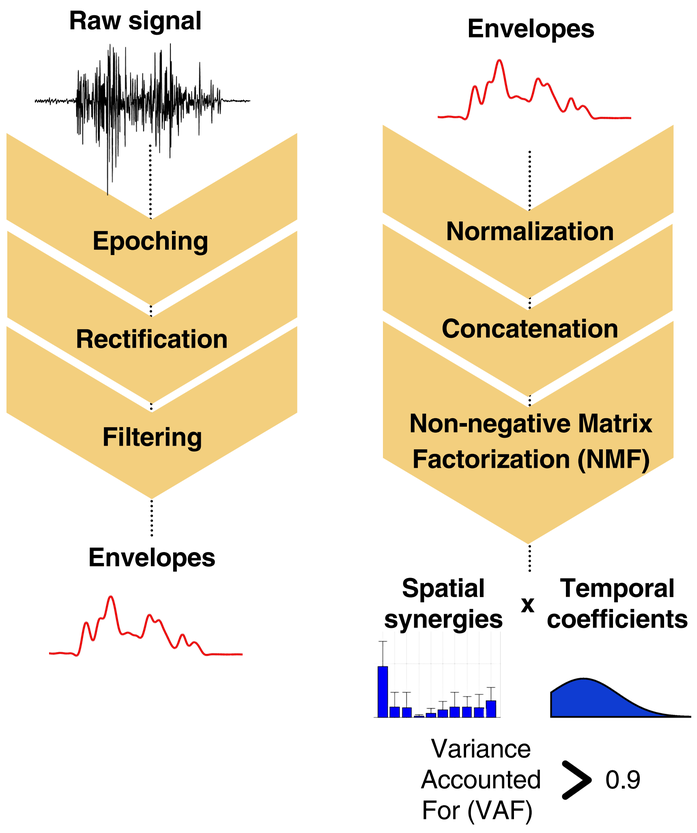
POPULATION

20 right-handed able-bodied subjects (10 males, 10 females, age 31.6 +/- 6.2 yo)

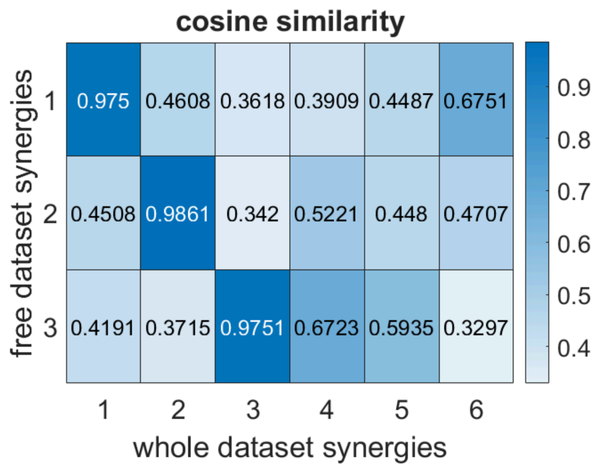
EXPERIMENTAL PROCEDURE



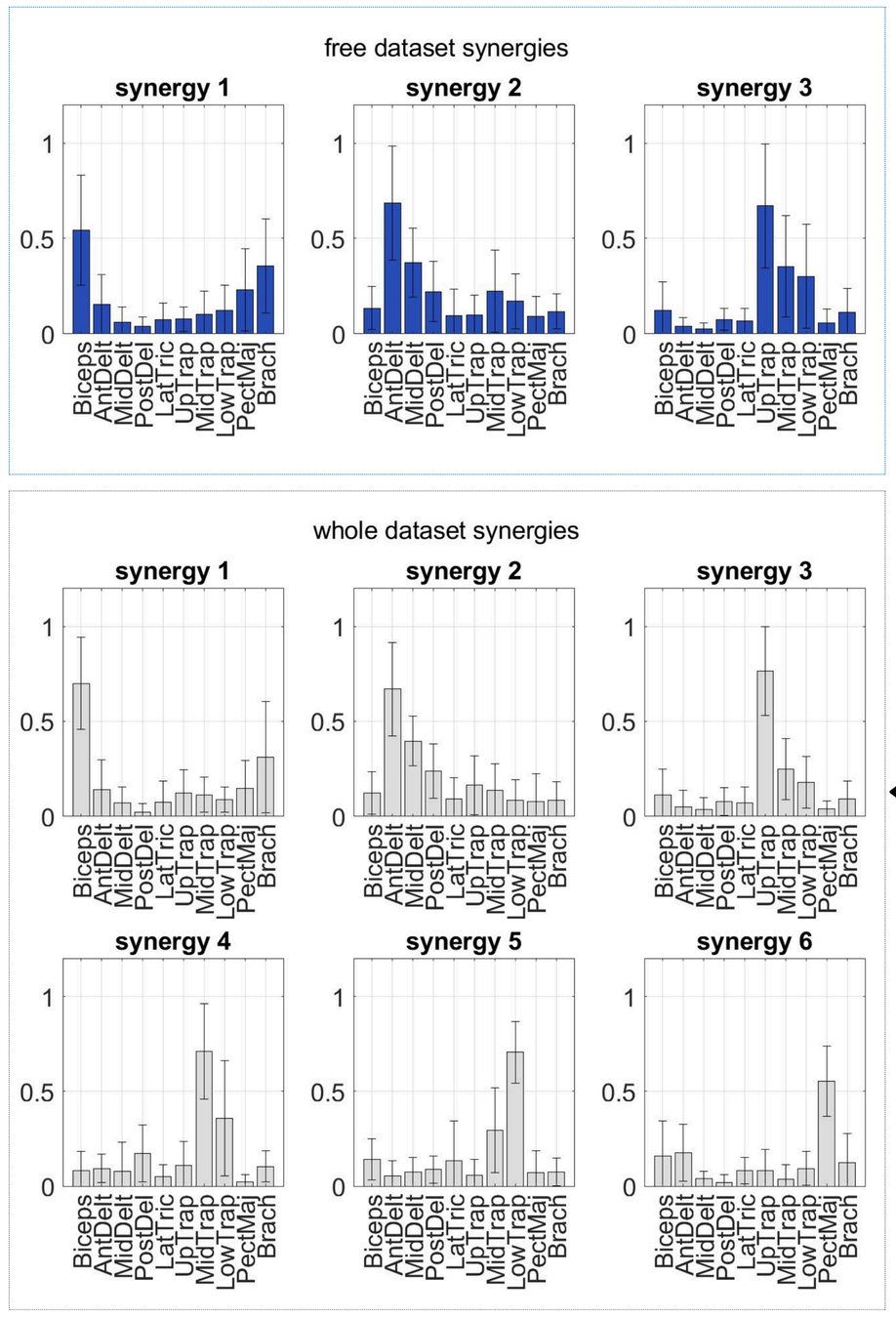
SYNERGIES EXTRACTION



SPATIAL SYNERGIES SIMILARITY



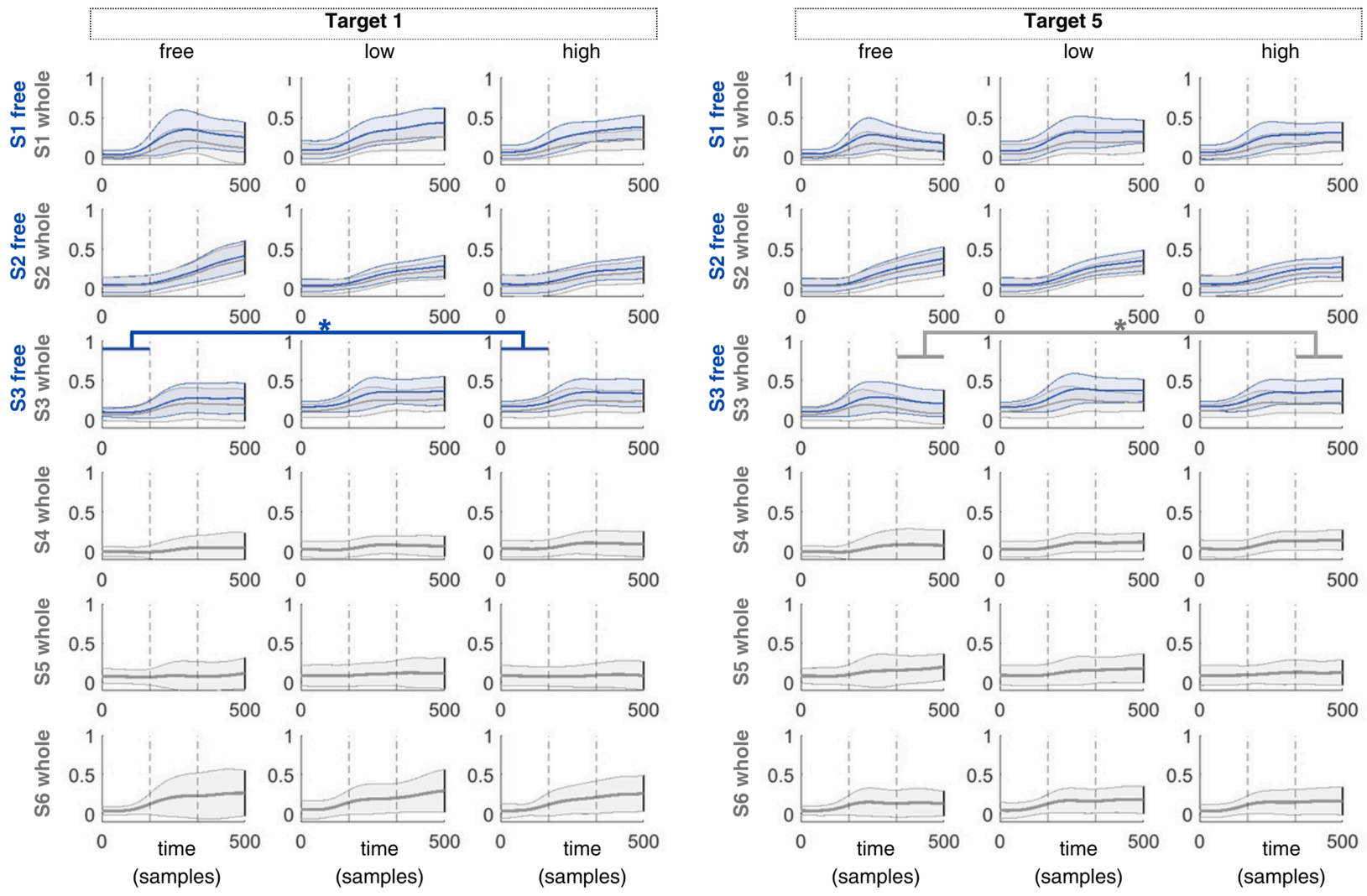
SPATIAL SYNERGIES



TEMPORAL COEFFICIENTS VARIATIONS

Synergy	Target	Phase	Conditions	p-value
S3_free	1	initial	free vs high	0.00039
S3_free	2	initial	free vs high	0.00052
S3_free	9	final	free vs high	0.00045
S3_whole	5	final	free vs high	0.00039

TEMPORAL COEFFICIENTS



DISCUSSION

- The fundamental synergistic structure of reaching is preserved when movement is assisted by Float.
- Float assistance modulates motor control: it appears fragmented into the activation of single muscles or couples of muscles.
- Assistance provided by joint 4 results in a visible (although not statistically significant) reduction in the activation of synergy 2 (responsible for elbow flexion).
  → Similar to bodyweight support.
  → May counteract abnormal muscle couplings in stroke survivors [5].
- High assistance increases the activation of synergy 3 (responsible for scapula elevation).
  → The users perceive Float's weight on the shoulder.
  → Improving friction compensation or introducing assistance on joint 2 could reduce this effect.

FUTURE WORK

- Involvement of post-stroke subjects.
- Separation of tonic and phasic components of muscle activation.

REFERENCES

[1] V. Longatelli et al., "A unified scheme for the benchmarking of upper limb functions in neurological disorders," J NeuroEngineering Rehabil, vol. 19, no. 1, p. 102, Sep. 2022.
[2] E. Bizzi, V. C. K. Cheung, A. d'Avella, P. Saltiel, and M. Tresch, "Combining modules for movement," Brain Research Reviews, vol. 57, no. 1, pp. 125–133, Jan. 2008.
[3] F. Garro et al., "NeBULA: A Standardized Protocol for the Benchmarking of Robotic-based Upper Limb Neurorehabilitation," in 2023 45th Annual International Conference EMBC, pp. 1–4.
[4] S. Buccelli et al., "A gravity-compensated upper-limb exoskeleton for functional rehabilitation of the shoulder complex," Applied Sciences, vol. 12, no. 7, p. 3364, Jan. 2022.
[5] T. M. Sukal, M. D. Ellis, and J. P. A. Dewald, "Shoulder abduction induced reductions in reaching work area following hemiparetic stroke: neuroscientific implications," Exp Brain Res, vol. 183, no. 2, pp. 215–223, Nov. 2007.