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XXXVII Cycle

Robust control of Hannes upper-limb prosthesis for an improved human-machine interface

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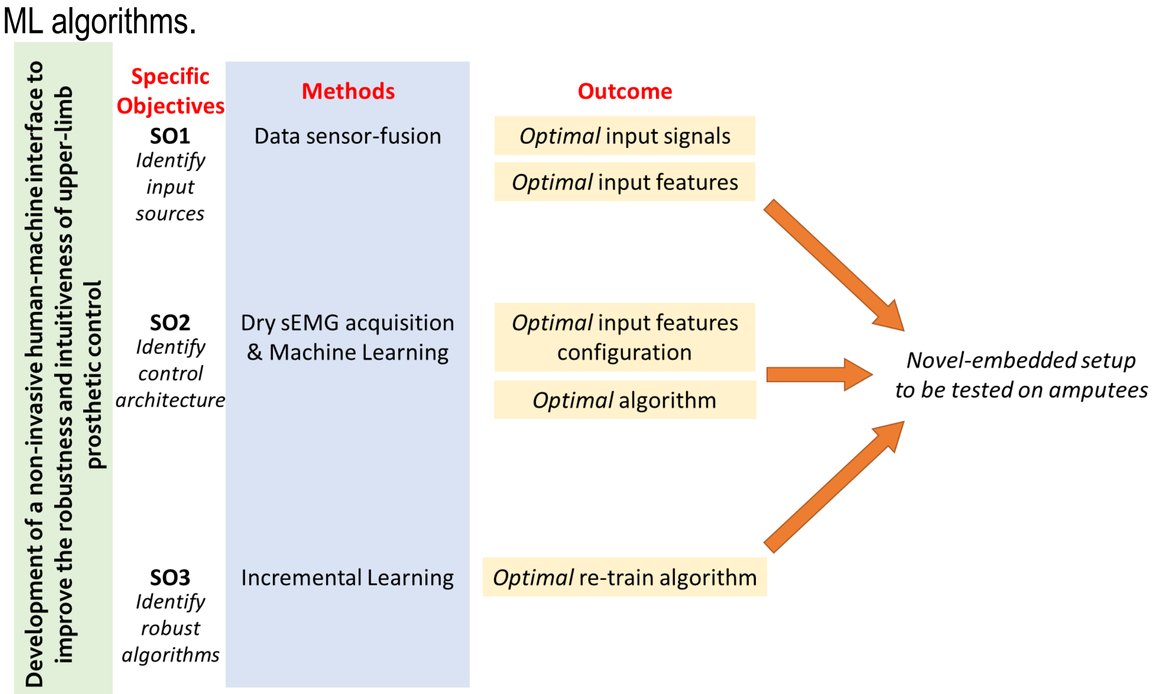
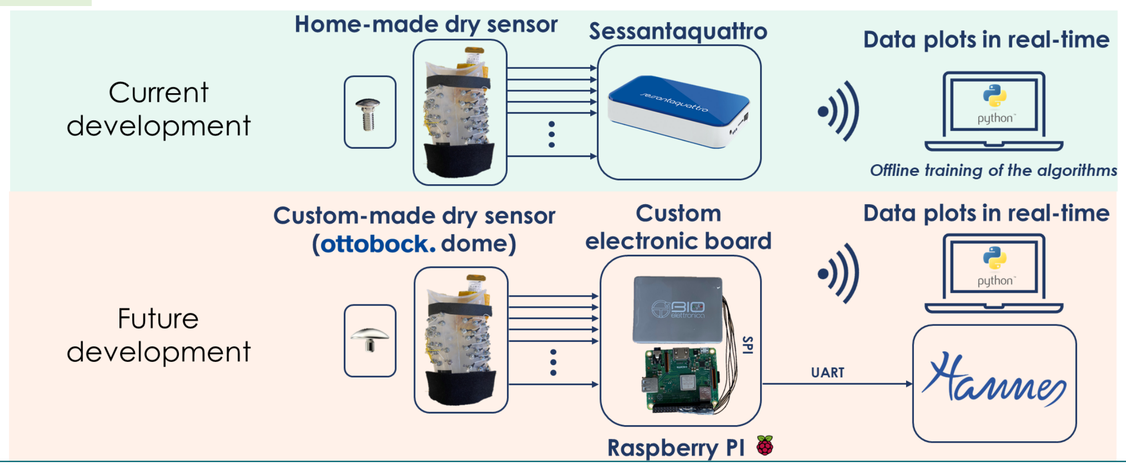
Research context and motivation

Hands and arms allow to operate the world around us, permitting both to interact with the environment and to help in social situations. The loss of an upper limb incredibly lowers the quality of life, leading to severe impairment in daily-living operational functionality as well as to psychological damages. Researchers have thus investigated the possibility to improve the intuitiveness of prosthetic control by exploiting machine learning (ML) algorithms. However, despite promising results, pattern recognition-based control is not yet applied in prosthetic applications, due to its lack of robustness along multi-days usage.

Addressed research questions/problems

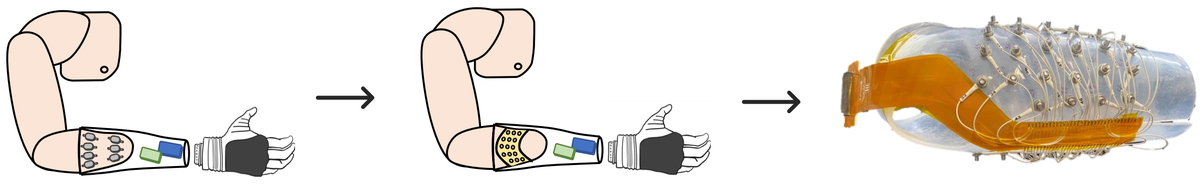
Prosthetic control based on myoelectric activity aims at intuitively translate motor commands from stump muscles, into prosthesis movements. The biggest issue lies in the variability of the surface electromyographic (sEMG) input signals, which forces the user to regular training of ML algorithms.





Novel contributions

- ***SO1, SO2 –*** *Increase source information:* augment the number sEMG sensors around the forearm to decode a higher number of movements. This aims at making the control more intuitive and more natural;
- ***SO3 -*** *Improve the multi-day usage*: ML algorithms are highly performing immediately after training, but deterioration of the input signal or subsequent doffing/donning of the prosthesis can lead to misclassifications. I will investigate the application of incremental learning algorithms on EMG data coming from the novel dry-setup.

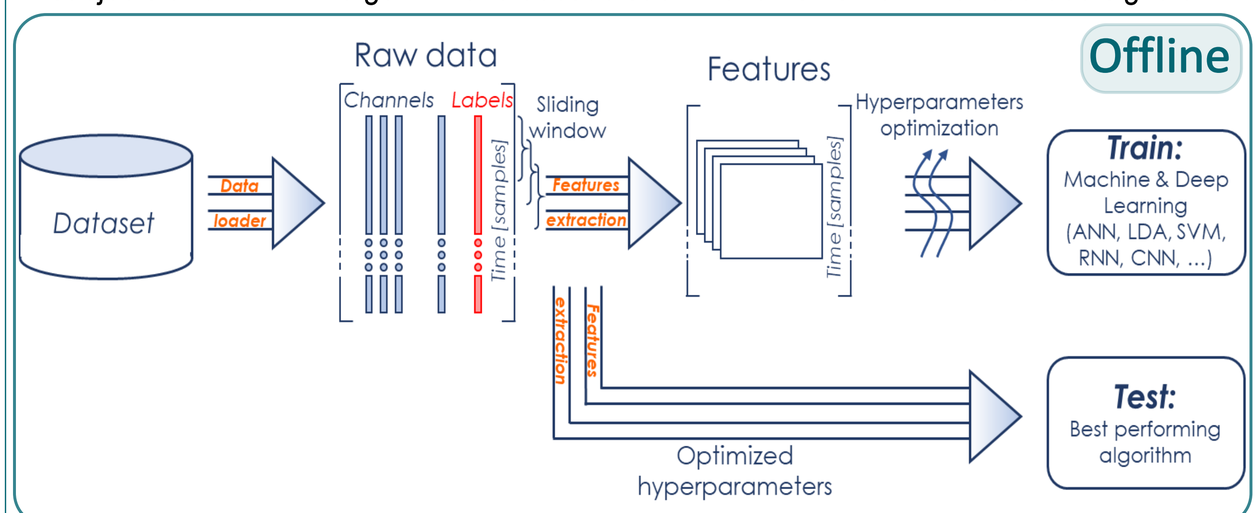


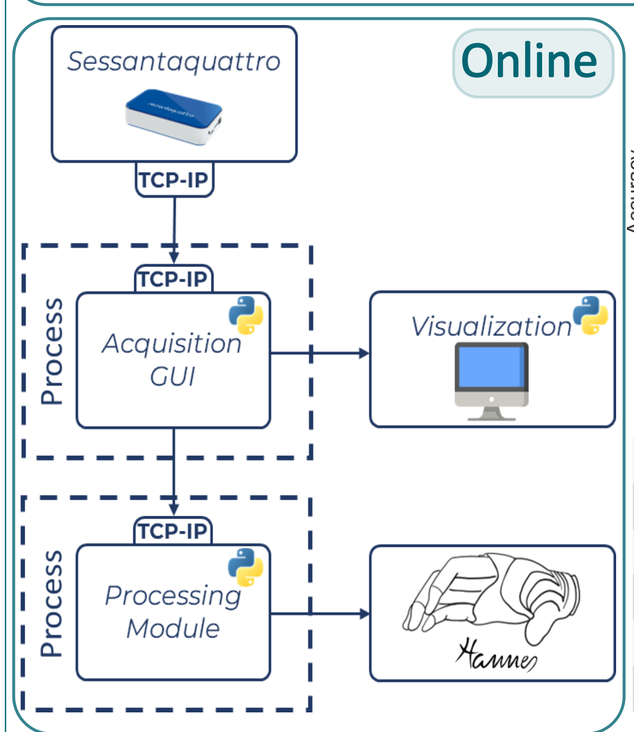
Submitted and published works

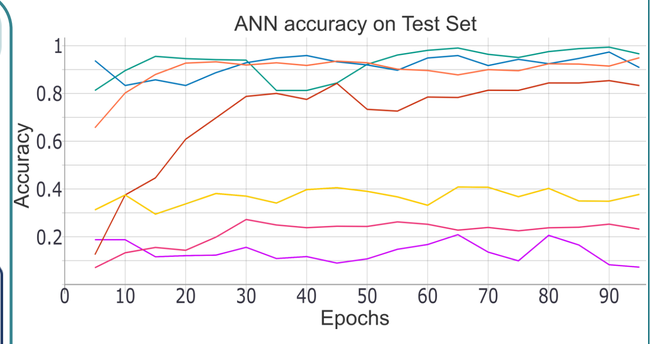
- Di Domenico et al., "*Hannes Prosthesis Control Based on Regression Machine Learning Algorithms*", IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2021, pp. 5997-6002, doi: 10.1109/IROS51168.2021.9636391.
- A. Marinelli, N. Boccardo. F. Tessari, D. Di Domenico et al., "*Upper Limb Prosthetic Control: A Review on Current Issues and Upcoming Breakthroughs*", IOPscience - Progress in Biomedical Engineering

Adopted methodologies & Results

- ***SO2:*** collect EMG signals from the whole forearm during upper-limb movements of healthy subjects and train ML algorithms to decode such movements from the recorded signals.

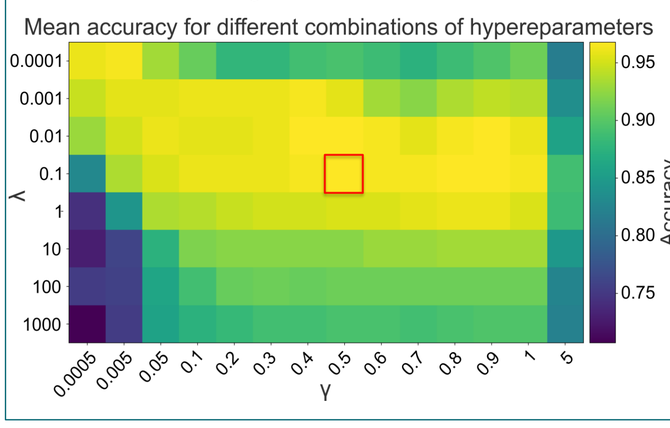


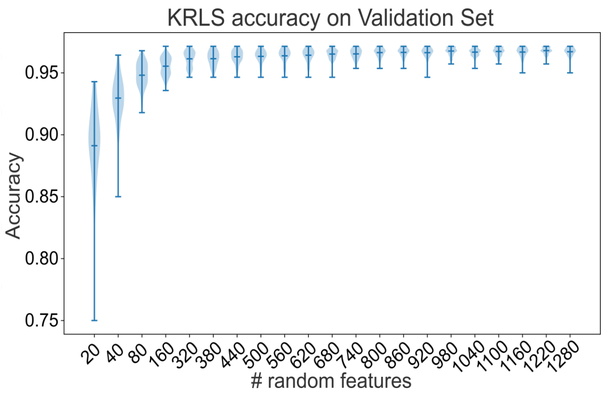




Learning rate	1e-5	1e-5	1e-4	1e-4	1e-3	1e-2	1e-3
Batch size	16	128	32	64	64	32	64
Window [ms]	200	300	200	100	200	200	100
Increment [ms]	100	5	100	50	5	50	50
# layers	2	2	2	2	2	2	2
# neurons	16	16	128	16	64	128	128

- ***SO3:*** starting from the novel dry-acquisition setup, study the applicability of incremental learning algorithms in order to allow the multi-days usage of the prosthesis leading to a reduced training time





Future work

I will develop a new upper-limb prosthetic device, and I will assess whether it can be used by amputees during their daily-life activities, proving to be robust and reliable. I will specifically investigate if this approach can lead to higher acceptance of advanced control systems for prosthetic applications. The aim is to both increase the number of classes to be identified (e.g., adding the thumb movements and tridigit grip) and implement an adaptable model able to deal with changes in the input signals.

List of attended classes

- 01RRPRV – Lean startup e lean business for innovation management (19/4/2022, 20h)
- 01RISRV – Public speaking (05/1/2022, 5h)
- 02LWHRV – Communication (24/12/2021, 5h)
- 01UNXRV – Thinking out of the box (05/1/2022, 1h)
- 02SFURV – Programmazione scientifica avanzata in matlab (21/4/2022, 30h)
- 01UJUIU – Human-Ai Interaction (9/2/2022, 25h)
- 01TRARV – Big data processing and programming (23/3/2022, 20h)
- Summer School in Neurorehabilitation (12/6/2022, 30h)
- Machine Learning Crash Course (27/6/2022, 20h)

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