

# Analysis and Modelling of Novel Surface Electromyography Signals

Fantin MELMOUX

Bachelor thesis 2025

Microengineering – Biomedical Engineering

Professor : Philippe POTTY

Expert : Jean-Claude VUILLEUMIER

## Description

This project explores non-invasive muscle source localisation via High-Density surface Electromyography (HDsEMG) using the COSIMA prototype, an innovative dry-electrode device, developed at the Centre suisse d'électronique et de microtechnique (CSEM). The project consists of developing and validating methods for muscular imaging, including signal preprocessing, modelling, and analysis. sEMG signals were recorded from the forearm during hand contractions and compared with an open-source dataset. Both datasets were preprocessed, normalised, and transformed to enable surface and volume muscular imaging.

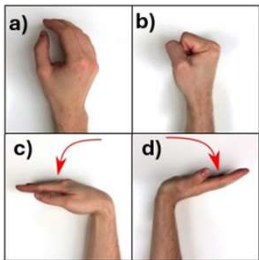


Figure 1: hand contractions

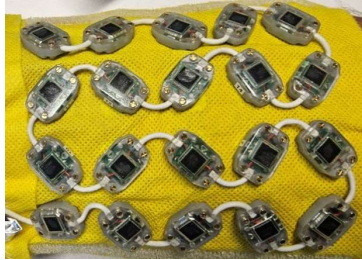


Figure 2: COSIMA device

## Progress

This three-month project was structured into five phases:

- **Phase 1 - Initiation:** defined tasks, explored concepts, reviewed literature and set up an initial program
- **Phase 2 - Model development:** created a forearm forward model for sEMG source localisation
- **Phase 3 - Open-access data analysis:** analysed open-access datasets for model validation
- **Phase 4 - COSIMA data analysis:** processed sEMG data from the COSIMA device
- **Phase 5 - Results analysis:** compared results, discussed clinical relevance and performed statistical analysis

## Results

Forearm muscle activation was successfully localised using open-source data in combination with advanced algorithms and models. Surface heat maps consistently corresponded with anatomical expectations. Although the COSIMA prototype had certain limitations, it demonstrated strong performance in acquiring sEMG signals, facilitating muscular imaging.

Applying volume imaging to the open-source data further revealed dynamic three-dimensional patterns of muscle activity. MRI alignment and accurate 3D forearm geometry were essential for validating the estimated source locations, confirming their anatomical accuracy (see Figures 3 and 4).

However, the models exhibited low sensitivity in detecting muscles involved in different types of hand contractions. Furthermore, noticeable inter-subject variability was observed, highlighting areas for future improvement.

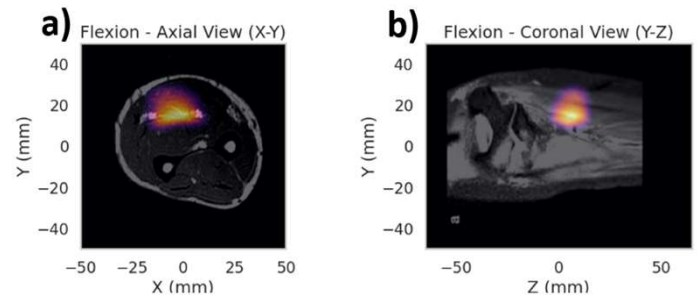


Figure 3: MRI images illustrating the localisation of muscular activity during wrist flexion: a) Axial view, b) Coronal view

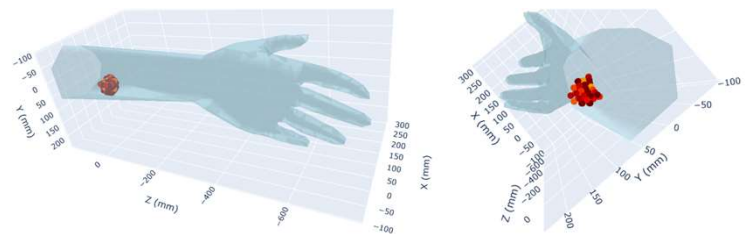


Figure 4: 3D geometry of the forearm, localising muscular activity on the anterior side during wrist flexion

## Conclusions and outlook

This project successfully localised forearm muscle activation using sEMG signals and modelling techniques. The COSIMA prototype demonstrated the acquisition of sEMG signals, enabling muscular imaging. The putEMG dataset was crucial for validating volume muscular imaging models, revealing anatomically consistent muscle activity. Future work involves refining COSIMA's design, improving the models, and exploring machine learning for applications such as prosthesis control and neuromuscular diagnostics.