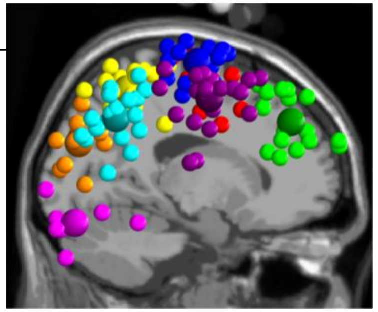
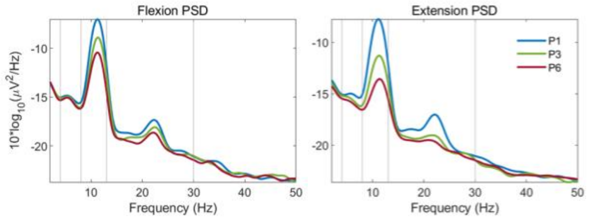
Classification of Exoskeleton Conditions using Machine Learning on EEG Signals

TECHNISCHE UNIVERSITÄT DARMSTADT

Master Thesis



Short Decription: Assistive robotic systems, such as exoskeletons, have emerged as promising tools for enhancing human mobility, performance, and comfort. However, to fully harness their benefits, it is crucial to tailor these devices to the specific needs and subjective preferences of individual users. Brain signals, measured through electroencephalography (EEG), provide a non-invasive and rich source of information that can reflect subjective evaluations and cognitive states of users interacting with assistive devices. To begin exploring this potential, we initially conducted a semi-stationary study aimed at minimizing movement-related EEG artifacts, thus assessing the feasibility of using brain signals as feedback for controlling exoskeleton assistance. In a previous experimental study [1] conducted at the *Lauflabor Locomotion Lab*, EEG, Electromyography (EMG), and knee angle data were collected from participants performing a knee flexion-extension task while tracking a moving reference path displayed on a screen. Participants wore a one-degree-of-freedom knee exoskeleton equipped with Pneumatic Artificial Muscle (PAM), where the PAM's pressure level was varied to modify the physical demand of the task.



Project Goals:

- Explore and implement machine learning methods, especially *Transformer-based models* and *hybrid architectures*, to classify exoskeleton assistance conditions (PAM pressure levels & subjects scores) using EEG signals.
- Evaluate and optimize the classification performance of various models.
- Investigate the interpretability of trained models to identify significant EEG features corresponding to different exoskeleton conditions.

Requirements:

- Strong interest in machine learning, neural signal processing, and biomechanics.
- Experience with Python programming,
- Familiarity with PyTorch/TensorFlow, is beneficial but not strictly required.

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[1] Mahmoudi, A., Khosrotabar, M., Gramann, K., Rinderknecht, S., & Sharbafi, M. A. (2025). Using passive BCI for personalization of assistive wearable devices: a proof-of-concept study. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*.