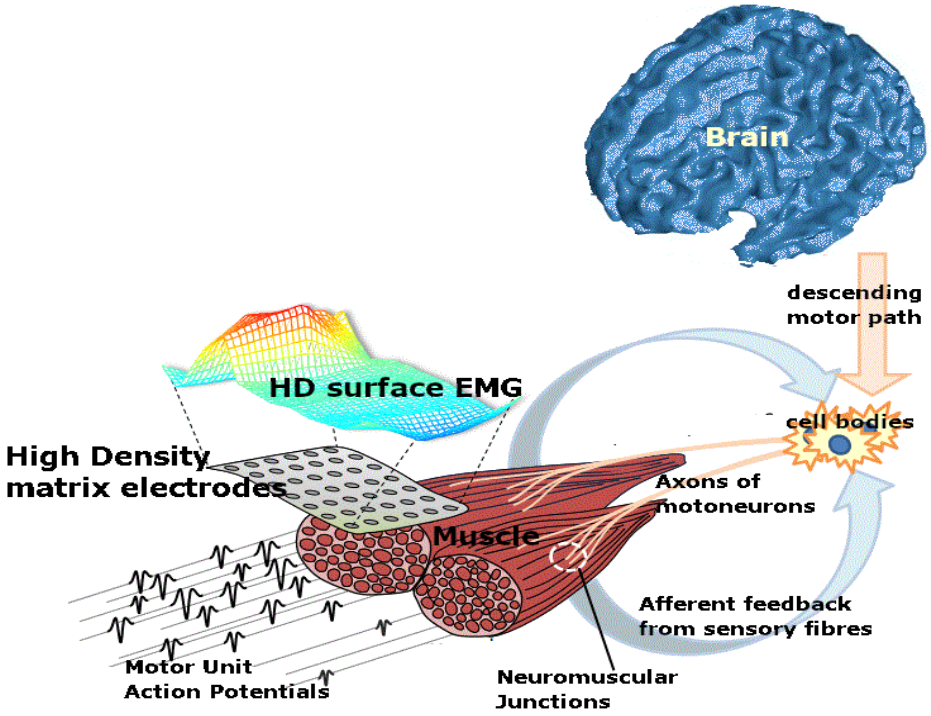
Postdoctoral position

Data science methods for human muscular investigation using multidimensional electromyographic device



Description of the project in plain language

The aim of this project is to develop new fatigue indicators of the neuromuscular command for ecological conditions of physical activity. The dedicated tool for its study is the measurement of the electrical activity of the muscle, called electromyographic activity (EMG). In everyday life, physical activities are dynamic, which makes the measurement and definition of EMG indicators problematic. Among the problems identified, EMG is corrupted by noise and artefacts and the signal properties vary over time. We therefore propose, using new high definition measurement techniques, to improve denoising and refinement of the acquired signals before developing new fatigue indicators based on changes in the EMG signal propagation.

Project background and objectives - State of the art - Project description and expected results

ATHENA european university and the University of Orléans, FR, offers a one-year post-doctoral position in the development of tools for muscular fatigue study and Neurophysiological investigations of Peripheral Nervous System medical **(to begin no later than September 1st, 2022).** The proposed subject is in line with the research carried out by the SIGNAL team of the PRISME laboratory over the last twenty years on the processing of electromyographic signals (EMG). **The present application is**

part of a dynamic collaboration with Pr. Alès Holobar from the University of Maribor, whose work relates to our subjects of interest. The latter are very innovative and recognised in the scientific community dealing with EMG signals.

This project is to develop processing technique with the aim of defining robust fatigue indicators extracted from the EMG signal while the latter is collected under conditions of dynamic activity.

EMG has been widely used to gain fundamental knowledge on neuromuscular control ***(Farina et al., 2014)*** and on neuromuscular fatigue ***(Halin et al., 2003) (Farina et al., 2008) (Ravier et al., 2015)***. Under dynamic activity, which is the main part of common activities (walking, running, cycling etc.), EMG signal is more corrupted. Firstly, due to limb accelerations and relative motion between sensor and the muscle under study, EMG is polluted by various noises and artefacts. Secondly, due to the "cross-talk" phenomenon, EMG signal is contaminated by the activity of nearby muscles. Thirdly, due to the sporadic muscle activities in such conditions, EMG signal is highly non-stationary.

This is why it is first necessary to pre-process these signals in order to isolate and refine the activity of the targeted muscle. For this work, we will take advantage of the evolution of high density matrix EMG (HD-EMG) non-bulky embedded measurement technologies. This device will allow the development of matrix analysis techniques. Indeed, HD-EMGs will allow channel selection and recombination of relevant channels. For this, we will exploit the matrix measurements by performing tensor decomposition analyses ***(Nguyen et al., 2016) (Trung Thanh et al., 2021)*** as well as the use of learning method.

Following this grooming, we will develop different kinds of fatigue indicators taking into account the non-stationary nature of the EMG signal, including those derived from inter-channel delay estimation ***(Ravier et al., 2015)*** and multi-scale permutation entropy complexity estimation ***(Dávalos et al., 2019)***.

Consortium of the collaborative project

Two universities from Athena university alliance will be part of the project

University of Orléans, France: Laboratoire PRISME, équipe SIGNAL, EA 4229, Polytech Site Galilée, phone: +33 2 38 49 48 63, with 4 collaborators K. Abed-Meraim K (Pr, IUF), O. Buttelli (MCF-HDR), M. Jabloun (MCF) and P. Ravier (MCF-HDR) A. Holobar for the Maribor part in this project.

University of Maribor, Slovenia: System Software Laboratory, Faculty of Electrical Engineering and Computer Science, Koroska cesta 46, 2000 Maribor, phone +386 2220 7485, with A. Holobar (Pr).

Project programme

The project concerns the development of EMG indicators for the study of the neuromuscular fatigue in dynamic situations. It is based on matrix techniques, which allow us to go back to the elementary activities in order to have access to the

neuromuscular command. The work programme will take place in several phases. The first phase is the cleaning of the data and the selection and recombination of relevant channels. A second phase concerns the decomposition of the data by tensorial methods. The decomposition results can be compared with those obtained by the partner, with the aim of accessing the motor control. A third phase will be the development of multidimensional deterministic and stochastic methods for estimating the conduction velocity of muscle fibres, an indicator that is particularly relevant for the study of fatigue. A fourth phase will concern the characterisation of data complexity for fatigue. Particular attention will be paid to the evolution of these complexity indicators with respect to the conventional indicators used for the study of fatigue.

For phases 3 and 4, the algorithms will be developed on the one hand on the cleaned data and on the other hand after decomposition of the data into elementary activities.

Provisional timetable

The programme will be spread over 12 months with the following schedule, T0 being the starting date:

WP 1 (T0 - T0+3): data cleaning and selection of relevant channels

WP 2 (T0+3 - T0+6): decomposition of the data and comparison of the results with those from the partner's work

WP 3 (T0+6 - T0+12): development of deterministic and stochastic estimators for conduction velocity estimation

WP 4 (T0+6 - T0+12): definition and characterisation of complexity indicators

The tools developed will be experimented on real data. We should benefit from the partner's multi-channel EMG databases. If necessary, we are in position to carry out HD-EMG measures.

The applicant will be involved in one or more of these phases.

Risk assessment

Few risks are identified because of the extensive previous works and expertise in EMG signal processing of the present consortium (the signal team of the PRISME laboratory in Orléans and the System Software laboratory in Maribor)

Location

PRISME laboratory, IRAUS department, Signal Processing Team at University of Orléans (Polytech), FR (https://www.univ-orleans.fr/fr/prisme/la-recherche/axe-signal)
Some travels between Orléans and Maribor are planed.

Preferred Experience

You obtained a PhD in signal processing / statistics / machine learning and you are motivated by biomedical applications. You have some experience in one or many research domains related to complexity measures, tensorial methods, deterministic and stochastic estimators, decomposition methods.

Recruitment process (end for 30 June):

Please send your application along with a complete CV with the list of publications and contact information of at least one reference to philippe.ravier@univ-orleans.fr and Olivier.buttelli@univ-orleans.fr.
If selected, you will have interview with the team members.

The post doc will **begin no later than September 1st, 2022**.

References

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Nguyen, V.-D., **Abed-Meraim, K.,** Linh-Trung, N., 2016. New robust algorithms for sparse non-negative three-way tensor decompositions, in: 2016 24th European Signal Processing Conference (EUSIPCO), pp. 2151–2155.

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