Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

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PhD information	
Title	Multi-dimensional surface Electromyography signal processing with application to Parkinson's disease
Main topics regards to CSC list (3 topics at maximum)	III.7 Biomedical engineering

Required skills in science and engineering	Signal processing, statistics, electrophysiology, electronics

Subject description (two pages maximum)

Multi-dimensional surface Electromyography signal processing with application to Parkinson's disease

Nowadays, loss of autonomy associated to aging has become a major health issue. In particular, balance and gait troubles are sources of pronounced disability affecting durably and significantly quality of life. The prevalence of falls is even higher for neurodegenerative disorders such as Parkinson's disease (PD). Technological innovations have progressed considerably in response to the needs of people in vulnerable or at-risk situations, such as elderly populations. Such technology has served to maintain independence through progress in rehabilitation tools, intelligent housing, alarms, adaptive aids and communication technology.

To that aim, the Signal team of the PRISME laboratory in the University of Orleans has lead the **EcoTech** project, focusing on personalised medicine. The project targeted the development, integration and application of onboard sensor technology and appropriate data processing in order to characterise gait disturbances in ecological settings. The purpose is to detect and overcome risk situations for patients with Parkinson's disease by designing new clinical evaluation methods and tools to identify patient difficulties when walking and provide accurate measures of patient response to treatment. The project was embedded in an international scientific program granted by the French (**No. ANR-12-TECS-0020**) and Taiwanese National Research agencies. During this project, we have developed a specific system composed by embedded/onboard biosensors (electromyography, accelerometer and inertial motion unit), acquisition systems, and specific signal processing software to record simultaneously and process (Toolbox EcoTech) several pertinent biomarkers.
We have shown that the developed device coupled with the analytical software solutions developed in the EcoTech Toolbox now allows studying and following patients with gait disorder and makes available gait monitoring of the Parkinson's disease progression, even in daily life, but with a still limited sight. Indeed, new and reliable motor coordination indicators need to be further developed useful for describing muscular synergies (for example to determine instantaneous muscle activity interactions). Such indicators come from biosensors measurements with appropriate processing developments. This constituted the challenge of the current PhD proposal.

Our Signal team has developed strong skills on processing bio-electrical signals, namely the electromyography and electro-cardiography signals for biomedical purposes (**see the reference list next page**). Several PhD theses related to this topic have been defended within our team. Some of the developed methods have focused on the estimation of the conduction velocity of motor unit action potentials. This conduction velocity is a useful tool for the assessment of neuromuscular fatigue states and motor disorders. Others have focused on fractal indicators for understanding the force impact on the sEMG. Others have focused on the sEMG cyclostationarity properties used for blind source separation in order to retrieve the elementary activities of the motor unit action potentials.

The PhD proposal will contribute to the development of new robust and efficient tools for multi-dimensional EMG signal processing in Pakinson's disease application. The tools to be developed should take into account the multi-sites EMG recordings and be capable of dealing with the EMG nonstationarity acquired under dynamic conditions (gait). The strategy must take account the multi-joint limb variations involved during locomotion and consequently a more comprehensive approach has to be implemented to identify correlated changes of the multi-dimensional EMG signal. Matrix factorization techniques provide a coherent framework that allows to address this concern and will be the starting point of this thesis proposal.

List of publications of our team regarding bioelectric data processing

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Parry R, Buttelli O, Riff J, Sellam N, Vidailhet M, Welter ML, Lalo E, "The whole perimeter is difficult": Parkinson's disease and the conscious experience of walking in everyday environments, Disability and Rehabilitation, Published online: 19 Jun 2018

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Luu GT, Boualem A, Duy TT, **Ravier P**, Buttelli O (2018) Time varying delay estimation applied to the surface electromyography signals using the parametric approach, Fluctuation and Noise Letters, 17, 1850015 [34 pages]

Roussel J, **Ravier P**, Haritopoulos M, Farina D, Buttelli O (2017), Decomposition of Multi-Channel Intramuscular EMG Signals by Cyclostationary-Based Blind Source Separation, IEEE Transactions On Neural Systems and Rehabilitation Engineering, Vol. 25, n° 11, pp. 2035-2045

Messaoudi N, Bekka RE, **Ravier P**, Harba H (2017) Assessment of the non-Gaussianity and non-linearity levels of simulated sEMG signals on stationary segments, Journal of Electromyography and Kinesiology, Volume 32, pp. 70-82

Lalo E, Riff J, Riff J, Parry R, Jabloun M, Roussel J, Chen CC, Welter ML, Buttelli O (2016) Design of technology and technology of design. Activity analysis as a resource for a personalized approach for patients with Parkinson disease. IRBM

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Parry R, Aupetit S, Buttelli O, Riff J, Welter ML, Lalo E "Studying falls in real situations: Coupling subjective experience and biomarkers in the design of innovative methods", in Advances in Science, Technology, Higher Education and Society in the Conceptual Age: STHESCA Edited By Tadeusz Marek Published by AHFE Conference © 2014

Roussel J, Haritapoulos M, **Ravier P**, Buttelli O. A New Cyclostationarity-Based Blind Approach for Motor Unit's Firing Rate Automated Detection in Electromyographic Signals. IEEE-EMBS International Conferences on Biomedical and Health Informatics, Spain 2014

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Jabloun M, **Ravier P**, Buttelli O, R Lédée, R Harba, LD Nguyen (2013) A generating model of realistic synthetic heart sounds for performance assessment of phonocardiogram processing algorithms. Biomedical Signal Processing and Control, 8: 455-465

Luu GT, **Ravier P**, Buttelli O (2013) Comparison of maximum likelihood and time frequency approaches for time varying delay estimation in the case of electromyography signal The International Journal on Applied Biomedical Engineering

Luu GT, **Ravier P**, Buttelli O (2012) The generalized correlation methods for estimation of time delay with application to electromyography, Vietnam Academy of Science and Technology Journal of Science and Technology, 50(5A), 59-64.

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Luu GTh, **Ravier P**, Buttelli O. Comparison of Maximum Likelihood and Time Frequency Approaches for Time Varying Delay Estimation in The Case of Electromyography Signals. 6th Biomedical Engineering International Conference, Thailand 2012

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