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Presentation Title

Non-invasive spinal interfacing for rehabilitation applications

Abstract:

Over the past few decades, the field of motor rehabilitation has been rapidly developing, mainly as a result of general technological advancements and deeper understanding of human physiology. Lately, however, this progress has somewhat slowed down and one of the culprits for it seems to be our inability to have an unobstructive yet informative access to the underlying neural drive as well as gain detailed and robust insight into the impact that the rehabilitation process is having on it.

Many modern rehabilitation technologies and methods rely on close and intimate interaction with patients. In fact, they observe, quantify, and react to the changes in the patient's neural output as therapies take place. To that end, surface Electromyography (sEMG) has clinically been one of the most widely considered interfacing modalities in modern neurorehabilitation, as it offers a non-invasive

and minimally intrusive way of intimate observation of the underlying neural activity. However, this convenience comes at a cost of information quality, since the observed signals provide only a limited overview of all the intricacies that the neural drive carries. Majority of the information loss originates from the fact that the traditional EMG signals are actually a rather blurry representations of the neural dirve itself. They are comprised of the summative activity of convoluted and filtered out action potentials coinciding with the contractions of muscles/muscle units in the proximity of the EMG recording sites.

To remedy this lack of fidelity, an attempt to untangle the actual contributions of individual motor neurons in the spine from the retrieved EMGs can be made. With this idea in mind, an EMG decomposition method, which combines high-density recordings (HD-EMG) and the advanced blind source separation methods, has been proposed. Leveraging the high number of observations, an attempt is made to deconvolve the recorded EMGs and monitor the behaviour of the underlying sources of activity (spinal motor neurons). With such interface we can aim to observe the rehabilitation induced neural changes at the level of single motor neuron spikes, and, as already suggested by a number of studies, have a substantial impact on the way we apply, evaluate, and design rehabilitation methods and technologies.

Short CV:

Ivan Vujaklija is an assistant professor at the Department of Electrical Engineering and Automation at Aalto University in Finland where he runs the Bionic and Rehabilitation Engineering research group. He holds a degree in Electrical Engineering and Computer Science from the University of Belgrade, and an M.Sc. degree in Biomedical Engineering from the University of Lübeck. In 2016 he obtained his PhD degree in human medical sciences at the University of Göttingen, while working as a research assistant at the Institute of Neurorehabilitation Systems. From 2012 until 2014 he worked for

Ottobock Healthcare GmbH, one of the world-leading prosthetic manufacturers. In 2014 and 2015 he was a research fellow at Arizona State University and Medical University of Vienna respectively. From 2017 until 2018 he has been working as a research associate at the Department of Bioengineering at the Imperial College London. Prof. Vujaklija was a part of a team of researchers that pioneered techniques for non-invasive spinal interfacing for rehabilitation applications. The same team has successfully introduced a novel, technology driven surgical paradigm for limb reconstruction which is now becoming a clinical state of the art. His research interests include bio-signal processing, advanced control algorithms, prosthetics, rehabilitation robotics, and neural control of movement.