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Developing Adaptive Multipole Models for interference suppression in OPM recordings of spinal cord neurography

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A key motivator for the adoption of OPMs for neural recordings is that they allow recordings from multiple different electrophysiological sources simultaneously. Simultaneous recording from the brain (MEG) and spinal cord (MSG) has recently garnered interest [1,2], as it has the potential to facilitate research into cortico-spinal connectivity, furthering our understanding of sensorimotor processing and recovery following spinal cord injury. However, interference suppression must be carefully considered to advance this novel recording modality. Sources of physiological interference are larger in MSG than MEG, due to the close proximity of back muscles and the heart [3]. Additionally, the differing geometry of the torso by comparison to the head means that methods developed for OPM-MEG may not be appropriate for OPM-MSG. In this study, we evaluate the validity of Adaptive Multipole Modelling (AMM) [4] –a post-acquisition interference suppression method for OPM-MEG –for OPM-MSG and suggest an extension to improve its suitability for spinal cord recordings.

AMM is a spatial modelling technique based on spheroidal harmonic models of the magnetic scalar potential. It has been shown to be highly successful for suppressing interference in OPM-MEG recordings. We will show in simulation that, due to the geometry of the torso, spheroidal harmonic functions arising from a single origin point provide a poor description of expected spinal cord signals. We show that extending the internal model to include multiple spheroid locations improves this performance, increasing the minimum correlation between the original and modelled simulated signals (simulated from a 1-shell boundary element model of the torso [5]) from 0.51 to 0.83 for a 9th order model, reflected in a decrease of the Bayesian Information Criterion (BIC) from $-3.14e4$ to $-3.37e4$. We consider the impact of different model parameters, including the shape of the reference spheroids used to generate the model basis functions and the model complexity. We then empirically validate performance with median nerve stimulation recordings and quantify the change in SNR of the spinal response after multi-spheroid AMM.

In summary, we show that with a relatively small adaptation, AMM can be effective for interference suppression for neuromagnetic recordings from the spinal cord in simulation and empirically. This increases the feasibility of OPM-MSG recordings, opening up new research avenues into connectivity across the central nervous system.

References

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Authors: Dr MELLOR, Stephanie (1. Spinal Cord Injury Center, Balgrist University Hospital, University of Zurich, Zurich, Switzerland 2. Translational Neuromodeling Unit, Institute for Biomedical Engineering, University of Zurich & ETH Zurich, Zurich, Switzerland); SCHMIDT, Maike (Department of Imaging Neuroscience, UCL Queen Square Institute of Neurology, University College London, London WC1N 3AR, UK); Dr O'NEILL, George (Department of Neuroscience, Physiology and Pharmacology, University College London, London, UK); GUPTA, Sarvagya (Spinal Cord Injury Center, Balgrist University Hospital, University of Zurich, Zurich, Switzerland); SPEDDEN, Meaghan (Department of Imaging Neuroscience, UCL Queen Square Institute of Neurology, University College London, London, UK); DEMKO, Laszlo (Translational Neuromodeling Unit, Institute for Biomedical Engineering, University of Zurich & ETH Zurich, Zurich, Switzerland); Dr HEINZLE, Jakob (Translational Neuromodeling Unit, Institute for Biomedical Engineering, University of Zurich & ETH Zurich, Zurich, Switzerland); BARNES, Gareth (Department of Imaging Neuroscience, UCL Queen Square Institute of Neurology, University College London, London, UK); Dr TIERNEY, Tim (Department of Imaging Neuroscience, UCL Queen Square Institute of Neurology, University College London, London WC1N 3AR, UK); Prof. STEPHAN, Klaas Enno (Translational Neuromodeling Unit, Institute for Biomedical Engineering, University of Zurich & ETH Zurich, Zurich, Switzerland); Prof. FREUND, Patrick (Spinal Cord Injury Center, Balgrist University Hospital, University of Zurich, Zurich, Switzerland)

Presenter: Dr MELLOR, Stephanie (1. Spinal Cord Injury Center, Balgrist University Hospital, University of Zurich, Zurich, Switzerland 2. Translational Neuromodeling Unit, Institute for Biomedical Engineering, University of Zurich & ETH Zurich, Zurich, Switzerland)

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