# Functional neuroimaging: recording technologies and data analysis methods

Centre for bioelectric interfaces
NRU HSE
Myasnitskaya 20, 101
17 October, 2019

## Program

**Morning session: lectures by invited speakers**

10.00 - 10.05 Welcome word,
**Alex Ossadtchi, Director of the Center for Bioelectric interfaces, NRU HSE (Russia)**

10.05 - 10.55 Optically Pumped Magnetometers: Promises and Pitfalls,
**Tim Tierney, University College London (UK)**

11.00 - 11.50 Normal and abnormal oscillations in the cortico-basal ganglia network revealed by deep brain stimulation recordings,
**Bernadette Van Wijk, Amsterdam University (The Netherlands)**

**12.00 - 12.20 coffee break**

12.20 - 13.00 Interpretable neural networks for decoding electromagnetic brain measurements,
**Ivan Zubarev, Aalto University (Finland)**

**13.00 - 14.20 Lunch break**

**Afternoon session: lectures by HSE researchers**

14.20 - 15.05 Overview of the neuroimaging projects in the HSE's Center for bioelectric interfaces (1 - Interictal spikes as cortical waves, 2 - Cognigraph: imaging brain activity in real-time)
**Alex Ossadtchi, Director of the Center for Bioelectric interfaces, NRU HSE (Russia)**

15.05 - 15.25 Decoding subcortical BOLD signals from concurrently recorded EEG data,
**Ilia Mikheev, Center for Bioelectric interfaces, NRU HSE (Russia)**

15.25 - 15.45 PSIICOS family of methods for imaging cortical activations and their functional coupling (PSIICOS and Anti-PSIICOS beamforming), **Alex Ossadtchi, Director of the Center for Bioelectric interfaces, NRU HSE (Russia)**

15.50 - 16.30 Decoding ECOG, EEG and MEG with a novel and interpretable neural network,
**A. Petrosyan, V. Bulgakova, Center for Bioelectric interfaces, NRU HSE (Russia)**

**16.30 - 17.00 coffee break**

17.00 - 18.00 Recording HFOs invasivaley and non-invasively: significance, equipment, methods,
**Tommaso Fedele, Center for NRU HSE (Russia)**

18.00 - 18.30 Analysis of EEG during different stages of meditation,
**Maria Volodina, Center for Bioelectric interfaces, NRU HSE (Russia)**

## Invited speakers and abstracts

### *Normal and abnormal oscillations in the cortico-basal ganglia network revealed by deep brain stimulation recordings*

Bernadette Van Wijk

Deep brain stimulation is an effective treatment for patients with advanced movement disorders. It also offers a unique opportunity to record local field potentials from basal ganglia structures in humans. I will give a brief overview of physiological and pathological neural oscillations that have been found and argue that cross-frequency coupling could play an important role in understanding how symptoms of movement impairment in Parkinson's disease emerge. I will then present our efforts to unravel the origins of abnormal oscillations, both in terms of anatomy and function. This includes a spatial localization study with intraoperative recordings around the subthalamic nucleus, and a dynamic causal modelling study of simultaneous LFP and MEG recordings to infer how beta oscillations arise within the cortico-basal ganglia circuit. These studies give insight into the role of the basal ganglia in movement and movement disorders, and contribute towards optimization of deep brain stimulation treatment.

## *Optically Pumped Magnetometers: Promises and Pitfalls*

Tim Tierney

Optically Pumped Magnetometers (OPMs) have emerged as a viable alternative to Superconducting QUantum Interference Devices (SQUIDS) for measuring brain activity. Specifically, OPMs promise more signal, better spatial resolution and a more natural scanning environment. This means that new neuroscientific questions can be asked and answered with this technology. However, OPMs are not without their drawbacks. Primarily, they are incredibly sensitive to both the magnitude and variation of the magnetic field in which they are operated. This talk will overview the technical challenges we have faced in setting up an OPM lab for neuroscience applications as well as our proposed solutions. I will also highlight the strengths of OPMs in a number of areas including modelling and simulation work, imaging deep brain structures and presurgical planning for epilepsy.

## *Interpretable neural networks for decoding electromagnetic brain measurements*

Ivan Zubarev

Deep Neural Networks are typically used as a “black box” models in a variety of classification and regression tasks. Although efficient for out-of-sample prediction, such models typically provide very little insight into what patterns in the data contribute to their performance. Recently, we have introduced a simple and efficient convolutional neural network design optimized for extracting interpretable representations of the magnetoencephalographic (MEG) signals. We show that constraining the solution space to incorporate the prior knowledge about electromagnetic brain signals into the neural network structure can yield high performance and allow interpreting the patterns contributing to the model performance in a neurophysiologically meaningful way. These models can be efficiently applied for quick explorative analysis of these multidimensional measurements. In this talk, I will briefly introduce the intuition behind these models and provide a typical explorative analysis pipeline implemented in open-source academic software. We will also discuss the current work extending their applications beyond MEG and classification tasks.