Contribution ID: **60** Type: **Talk**

Approaches to brain control

Monday 9 September 2024 16:30 (1 hour)

Perturbing brain activity, e.g. through stimulation or brain-computer interfaces, can help us investigate brain mechanisms and restore normal activity patterns in subjects affected by neuropathologies. A major goal of applied neuroscience is to go beyond current perturbation approaches, that are largely empirical, and develop more advance, data- and theory-driven schemes to achieve controlled perturbations of brain activity. Any such scheme requires two key elements: (1) a computational model of brain activity, informed by observed neural activity data (2) a mathematical framework to design perturbations causing desired effects. In recent years, several authors argued that a linear approach, combining linear models of brain activity and linear control theory, could provide both. In this lecture, we will first describe the linear approach and its severe limitations. Next, we will discuss how advanced machine learning approaches might be used to overcome some of these limitations, possibly laying the ground for more advanced and effective neurostimulation experiments.

Michele Allegra is a physicist with a broad interest for neuroscience. His main research topic is the analysis and modeling of functional networks in the brain. Upon completing a Ph.D in quantum physics at the University of Turin and the ISI Foundation in Turin, he changed research field, moving into data analysis for neuroscience. He joined the Statistical Biophysics sector of the International School for Advanced Studies (SISSA), Trieste, where he worked in Prof. Alessandro Laio's group from 2015 to 2018. His research activity within Laio's group focused on advanced clustering techniques and their application to the study of dynamically changing brain networks. He deepened his focus on neuroscience during his stay at the Timone Institute for Neuroscience in Marseilles (2018-2021), where he joined the BraiNets group led by Andrea Brovelli. In Marseilles, he focused on the analysis of brain imaging data, with the goal of characterizing functional networks in the brain and their disruption in major diseases such as stroke. His current research at the Laboratory of Interdisciplinary Physics and the Padua Neuroscience Center, University of Padua, focuses on applying statistics, information theory, and complex system modelling to obtain new insights in neuroscience research.

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Session Classification: Special Session NeuroAI