USC Viterbi School of Engineering
Ming Hsieh Department of Electrical and Computer Engineering

Seminar

Interpreting Brain Activity Through Connectivity Using Graph Signal Processing

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Better Representations for Artificial INtelligence (BRAIn)
IMT Atlantique

Monday, February 13, 2023
11:00am – 12:00pm

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Abstract: The application of graph theory to model the complex structure and function of the brain has shed new light on its organization, prompting the emergence of network neuroscience. Despite the tremendous progress that has been achieved in this field, still relatively few methods exploit the topology of brain networks to analyze brain activity. Recent attempts in this direction have leveraged on the one hand graph spectral analysis (to decompose brain connectivity into eigenmodes or gradients) and graph signal processing (to decompose brain activity "coupled to" an underlying network in graph Fourier modes). In this talk, we will describe two ongoing works that attempt at integrating knowledge from brain connectivity in order to decode and interpret brain activity. In the first contribution, we use functional connectivity graphs to define spectral convolution operators in a deep residual network trained on task decoding. We show how parameter pruning can be used to select the most important connectivity gradients for the task. In the second study, we analyze brain measured using high-density EEG during video watching, and perform an analysis using graph signal processing to estimate coupling and decoupling of source-localized electrophysiological activity on a functional connectivity graph. We discuss relationships between inter-subject correlation during video watching and structure-function decoupling at the individual level, and as a function of the underlying graph. The overarching goal of this line of work is to explore whether connectivity-informed analysis of brain activity can contribute to a better understanding of brain complexity as multimodal signals over networks.

Bio: Nicolas Farrugia (NF) obtained an electrical engineering degree at ENSEA, Cergy-Pontoise, in France, as well as a M.Sc. in Signal and Image processing, both in 2005. In 2008, he obtained a PhD at the Université de Bourgogne and Orange Labs, Grenoble, working on hardware implementation of deep neural networks. In 2010, NF moved to the field of cognitive neurosciences as a postdoctoral researcher, with a focus on the neurosciences of music. As a postdoc at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, he studied the effect of rhythm in the rehabilitation of Parkinson's Disease, as well as brain oscillations. He also did postdoctoral work on musical performance in drumming at the Music Performance and Brain Lab in Warsaw, and involuntary musical imagery in the Psychology Departement of Goldsmiths, University of London. NF published work in prestigious neuroscience and cognition journals such as "NeuroImage", "Network Neuroscience", "Memory & Cognition", and "Neuropsychologia". NF uses a wide range of cognitive neuroscience methods such as EEG, functional MRI, as well as behavioral psychology methods and motion capture. Since 2015, NF joined IMT Atlantique (previously known as Telecom Bretagne) to engage into a transdisciplinary effort, combining methods from Auditory Cognition, Neuroscience, Deep Learning, and Graph signal processing. Since 2016, he is part of the BRAIn team (Better Representations for Artificial Intelligence), together with Giulia Lioi, Bastien Pasdeloup, Vincent Gripon and Mathieu Leonardon.

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