Brain graphs: An Introduction to network analysis of brain imaging data

Organizers:
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Brains are complex, interconnected systems. Recent years have witnessed an unprecedented attempt to understand this complexity, supported by several large-scale efforts to map connectomes in a diverse range of species, at scales ranging from individual neurons and synapses to distributed systems spanning the entire brain. Graph theory, a branch of mathematics concerned with modelling systems of interacting elements, is a powerful framework that can offer a unified way of representing and characterizing these diverse data. The central assumption of graph theory is that any network can be modelled as a collection of nodes connected by edges. In the brain, the nodes can represent neurons, neuronal populations or large-scale brain regions and the edges represent some measure of structural, functional or effective connectivity.

The application of graph theory to neuroscientific data has provided new insights into the organizational properties of brain networks and their generative mechanisms, while also offering a platform for mapping, across the entire connectome, the effects of disease and other experimental manipulations. Graph theory will increasingly become an essential part of the neuroscientists' toolkit, as large, high-quality datasets on brain connectivity provided by initiatives such as the Human Connectome Project continue to be made available. An integrated and comprehensive educational workshop is both timely and necessary to ensure that researchers have access to methods that can maximise the value of these rich data.

This workshop will provide an integrated introduction to the key concepts and methods of the field. Topics covered include methods for constructing valid brain graphs; appropriate methods for characterizing the topological centrality of nodes, putative communication processes, the community structure of brain networks, and multilayer properties; and the use of appropriate statistics and null models.

Course Schedule:

8:00-8:35

An introduction to brain graphs

Alex Fornito, Monash Institute of Cognitive and Clinical Neurosciences, Monash University, Clayton, Australia

8:35-9:10

Network statistics and thresholding

Andrew Zalesky, Melbourne Neuropsychiatry Centre, The University of Melbourne, Melbourne, Australia

9:10-9:45

Paths, diffusion and communication in networks

Bratislav Misic, Montreal Neurological Institute, McGill University, Montreal, Canada

9:45-10:20

Modularity in static and dynamic networks

Sarah Muldoon, University at Buffalo, SUNY, Buffalo, NY, United States

10:20-10:35

Break

10:35-11:10

Centrality and hubs

Martijn van den Heuvel, Brain Center Rudolf Magnus, Dutch Connectome Lab, University Medical Center Utrecht, The Netherlands

11:10-11:45

Null models and generative models for brain networks

Petra Vértes, University of Cambridge, Cambridge, United Kingdom

11:45-12:00

Question and Answer