Exploring the interplay between dynamics and connectivity in large-scale neuronal networks

Massobrio Paolo
Paolo.Massobrio@unige.it
Via All'Opera Pia, 13 - 16145 Genova
(+39) 010353 - 2761

The spontaneous activity of cortical networks is characterized by the emergence of different dynamic states. Although several attempts were accomplished to understand the origin of these dynamics, the underlying factors continue to be elusive. The aim of this thesis is to explore whether peculiar connectivity rules can promote different dynamics.

Experimental evidences showed that dissociated cortical assemblies coupled to Micro-Electrode Arrays (MEAs) can exhibit scale-free distributions of neuronal avalanches, a hallmark of Self-Organized Criticality (SOC), thus demonstrating that they preserve self-organization properties featured by in vivo-formed cell assemblies. However, the determinants of the emergence of different dynamical states (critical, subcritical or supercritical) remain unclear. By using high density MEAs, experiments of spontaneous activity will be performed in order to correlate the emergent functional connectivity (evaluated by means of correlation-based methods) with the dynamic states (evaluated with SOC theory).

The activities of the thesis will require the use of an innovative experimental set-up which allows to simultaneously record the electrophysiological activity from more than 4000 microelectrodes. From a computational point of view, the analysis of connectivity and criticality will be performed using both existing and “to develop” algorithms.

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computational neuroscience, neuroengineering

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