Information transmission in random and modular neuronal networks

Cristina Masoller and Maria Masoliver Vila
Universitat Politècnica de Catalunya, Terrassa Campus, rbla. Sant Nebridi s/n, 08022 Terrassa, Spain

Despite intensive research, the mechanisms by which neurons encode information in spike trains remain poorly understood. Recent work has focused on how a FitzHugh-Nagumo neuron encodes a weak (subthreshold) sinusoidal signal, in a noisy environment [1], and on the impact of a second neuron, which does not perceive the signal [2]. By applying a symbolic time-series analysis method to the sequence of inter-spike-intervals (ISIs) [3], preferred and infrequent spike patterns were detected, whose probabilities encode information of both, the amplitude and the frequency of the weak signal.

Here we investigate whether this symbolic information-encoding mechanism is robust when we work with larger neurons ensembles. First we analyze how the signal is transmitted and encoded in a small random network and second in a small modular network (motivated by the modular structure of the brain). We assume that the weak signal is perceived by the neurons in only one of the modules, and the information is transmitted to the other modules in the form of more expressed and less expressed spike patterns. We analyse how the coupling parameters, the network size and its modular structure impact the encoding of weak periodic or aperiodic signals.

[1] J. A. Reinoso, M. C. Torrent, and C. Masoller, Emergence of spike correlations in periodically forced excitable systems, Phys. Rev. E **94**, 032218 (2016).

[2] M. Masoliver and C. Masoller, Subthreshold signal encoding in coupled FitzHugh-Nagumo neurons, Sci. Rep. **8**, 8276 (2018).

[3] C. Bandt and B. Pomper, Permutation entropy: A natural complexity measure for time series, Phys. Rev. Lett. **88**, 174102 (2002).