Local independence graphs to understand the functional connectivity in the brain

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In Neurosciences, one of the current challenge is to acquire a better understanding of the dynamics of the brain. To do that, neurobiologists study the action potentials (spikes) considered as the main code of the neuronal activity. In particular, by recording simultaneously the spike trains of several neurons, a synchrony phenomenon has been highlighted during some particular sensorimotor tasks. Among the most popular methods to detect those synchronizations, we can cite the Unitary Events method developed by Grün and collaborators [1]. Many developments of this method have been proposed, as MTGAUE [2], however due to various difficulties, such method does not answer the question: "how to identify in the neural network local independence graphs reflecting the functional connectivity". More precisely, if it is known that neurons are biologically almost completely connected, the question is now what are the neurons that are synchronized in response to a given stimulation and in which way.

This is the question we sought to answer by proposing a statistical methodology considering the multivariate Hawkes model and optimizing of a given penalized criterion to take into account the huge number of parameters and the relatively modest amount of data. The Hawkes processes take into account the possible interactions between neurons by introducing interaction functions from a given neuron i onto a given neuron j in the conditional intensities associated to the process. The aim of the penalized criterion is to estimate the interaction functions with parsimony to reconstruct a sparse local independence graph. Indeed it seems that only small assemblies of neurons are functionally connected. This explains why we prefer the Lasso criterion to the least square one (see the theoretical work of Hansen *et al.* [3]). With the RNRP team of Paris 6, we have tested the robustness of the method by considering networks simulated according to Hawkes processes or integrate and fire ones, and by varying the parameters of these models as the excitation or inhibition force. It appears from this study that the proposed methodology allows to find the connectivity graphs, even if the underlying model is not a Hawkes model. Some studies on real data are also in progress but early results look promising.

References

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