Paris-Rocquencourt centre
ARAMIS and MYCENAE teams

SUBJECT: Postdoc open position

TITLE: Modeling and analysis of neuronal activity and connectivity from in-vivo calcium imaging

MISSION AND ENVIRONMENT

The recent development of genetically encoded calcium indicators has enabled optically recording in-vivo the activity of multiple neuronal populations (1). An increasingly number of new data are being accumulated and the need of mathematical methods to understand them and extract relevant information is becoming a central issue (2). The ARAMIS and MYCENAE teams of the INRIA Paris-Rocquencourt centre are collaborating to develop new models and analytic tools for the characterization of complex neuronal activity and connectivity patterns. This multidisciplinary collaboration proposes to combine modeling approaches with signal processing and network theory to examine and simulate the dynamics of the neuronal activities and their interaction at the system level.

JOB OFFER DESCRIPTION

The job of the postdoc is to develop and validate mathematical models and analytic tools to characterize the activity of large distributed neuronal networks. The objective is to determine the biophysical mechanisms generating the dynamics of the calcium activity signals and to identify the organizational principles regulating the functional network formation.

In a previous study, we have designed a network model by coupling 3D individual dynamics of FitzHugh–Nagumo type to reproduce qualitative and quantitative specifications of the calcium activity recorded in-vitro on embryonic GnRH neurons from the rhesus monkey, both on the individual level (e.g. interpeak intervals) and the population level (synchronization events) (3). This model however was not designed to reproduce the spatial structure of the calcium dynamics.

In a more recent study, we have used Granger-causality estimates to construct directed functional networks between the activities recorded in-vivo from different neurons of the zebrafish spinal cord. Our analysis has revealed a characteristic hierarchical organization of the network hubs that supported established propagation of activity from rostral to caudal spinal cord (4). This, approach however could not distinguish the inhibitory or excitatory nature of the network links and was not optimized for very large networks. In addition, it was not exploited to validate alternative functional network models based on the spatial information of the nodes.

In the light of these open issues, the specific tasks of the postdoc are:

1) Designing models of calcium activity incorporating spatial structure of in-vivo data,
2) Developing functional connectivity methods to infer inhibition and excitation between a large number of neuronal signals,
3) Creating models incorporating the spatial information of the neurons to predict the functional network topology.

In the framework of an existing collaboration with the ARAMIS team at the *Institut du Cerveau et de la Moelle epiniere* (ICM), the "Optogenetic dissection of spinal circuits underlying locomotion" team, headed by Claire Wyart (INSERM) will provide data from zebrafish embryos to validate the models and the tools to be developed and will participate in steering the method development and interpreting the results from a neurobiological perspective.

SKILL AND PROFILE

The ideal candidate should have a solid background in computer science and/or applied mathematics and signal processing, enjoy high comfort levels when dealing with mathematical abstractions/techniques as well as programming (C or Octave-based preferably). A background in computational systems biology (with an emphasis on optical imaging) or in network analysis would be very welcome but not necessary. The ability and willingness to learn will do equally well.

BENEFITS

- Net monthly salary: around 2200 €
- Financial support from INRIA to catering and transportation expenses.

ADDITIONAL INFORMATION

- Location: Paris
- Duration: 12 months
- Availability: As soon as possible

CONTACTS

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REFERENCES

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