Metric Framework of Synchronous States Identification in Spiking Neural Networks | Daniil Radushev

Metric Framework of Synchronous States Identification in Spiking Neural Networks

Authors: Daniil Radushev (1), Olesia Dogonasheva (2), Boris Gutkin (3), Denis Zakharov (1)
Affiliations: (1) Higher School of Economics, Moscow; (2) Institut de l'Audition, Institut Pasteur, Paris; (3) École Normale Supérieure, Paris.

Abstract:
For many years, the investigation of synchronization properties of neural networks has been one of the most important directions of research in the synchronization theory. Among the main issues arising in the studies of neural networks' synchronous regimes is the demand for automatic tools of coherent state identification, since those are used to localize the synchronous states' existence regions in parameter spaces.

The traditional approach to the problem has been to identify the state based on a numeric estimate of the network activity coherence. While providing adequate tools for full synchrony/full asynchrony differentiation, this strategy lacks power for detailed description of partially synchronous states, which are the most relevant regimes for neuronal network function. In this work, we propose a new approach to the issue of neuronal network synchronous state identification — the Metric Framework.

Metric Framework interprets the network as a metric space and the activity parameters of its neurons as functions on that metric space. Through the identification of the regions of continuous change of the activity parameters, one locates the network's synchronous clusters. The data of the sizes, the locations, and the internal characteristics of those clusters form an exhaustive high-level profile of the synchronous state, allowing the researcher to draw interpretable and accurate conclusions about the network's dynamics.
This work was supported by the Russian Science Foundation (Grant No. 24-68-00030)