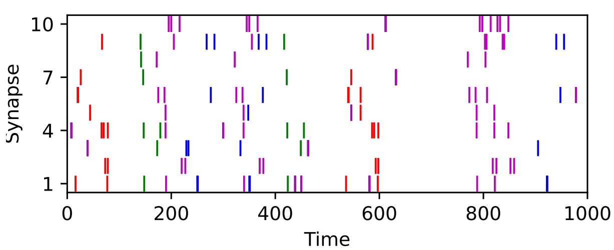
DECODING SPIKING MOTIFS USING NEURONS WITH HETEROSYNAPTIC DELAYS

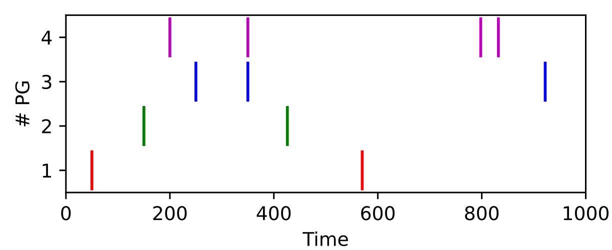
Camille Besnainou [1], *Antoine Grimaldi* [1], *Hugo J. Ladret* [1,2] and *Laurent U. Perrinet* [1,*]

[1] Institut des Neurosciences de la Timone, CNRS and Aix-Marseille Universite, Marseille, France
[2] School of Optometry, University of Montreal, Montreal, Canada
[*] laurent.perrinet@univ-amu.fr

The response of a biological neuron depends largely on the precise timing of presynaptic spikes that reach the basal dendritic tree. However, most neuronal models do not take advantage of this minute temporal dimension, especially in exploiting the variety of synaptic delays on the dendritic tree. A notable exception is the polychronization model [1], a recurrent model of spiking neurons including fixed and random heterosynaptic delays and in which the weights are learned using Spike-Time Dependent Plasticity. The output raster plot displays repeated activations of prototypical spiking motifs called “Polychronous Groups” (PGs). Importantly, these motifs seem to be highly relevant in experimental neuroscience (see for instance [2]). Here, by extending the model of [3], we develop a spiking neural network model for the efficient detection of PGs: By defining the generation of the raster plot as a probabilistic combination of PGs, we build and train the network in order to optimize the inversion of this generative model.



(a) Observed raster plot



(b) Raster plot of PGs

An example synthetic raster plot is generated in *(a)* as the combination of PGs whose timing and identity are drawn as a raster plot in *(b)*, here a superposition of 4 PGs projected on the synaptic space of 10 neurons and at an average rate of 3 Hz during 1000 ms. Observing spikes from *(a)*, the model decodes the identity and timing of PGs in *(b)*, which in turn we may use to color spikes in *(a)* with respect to that of the PG that most likely generated them.

A first result is to show in synthetic data the efficiency of such a scheme in detecting different PGs occurring at specific times. The representational capacity of the PGs is particularly high compared to traditional models of neuronal encoding using spiking frequency like that of [3]. Our second result is to propose a novel method for learning PGs in raster plots in a self-supervised manner. This was validated on synthetic data and we show results of this method when applied to neuronal data acquired in the visual cortex. Of particular relevance is the fact that the learned weights provide with an explainable factor between neural data and the occurrence of specific PGs.

References

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