Information Routing by Rate Fluctuations in Structured Neural Circuits

How neural circuits route information given their spatio-temporal dynamics is not well understood. Research on neural information routing tries to define how information is shared and transferred within a population of neurons (in a network) as well as between populations (in networks of networks). To this day, no theory comprehensively describes, in neuronal circuits, the dependencies of information routing patterns on the network components, the connectivity and external inputs.

In the thesis, we approach this gap with a theoretical-numerical study to define the basis for a potential formalization of information routing. We study a spiking neural circuit model for networks of networks, i.e. of populations of neurons, each in the balanced state (Vreeswijk and Sompolinsky, 1998) and ask how the spiking dynamics collectively act for routing information. In particular, we reveal in which form the fluctuations around mean rates contribute to information routing between populations. Specifically, this can be quantified using the measures of delayed mutual information (dMI) and delayed cross-correlation (dCC) between the rates of the populations. We characterize how changes in inter-population connectivity modify information routing patterns, and discuss the role of external inputs and synaptic delays in their generation. Overall, we define how to extract information between populations of spiking neurons from the fluctuations of their mean rates and we outline how these results can contribute to formalize the flexible routing of information in neural circuits.