Proposal for a research internship (M2)

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Thesis possibility after internship: YES
Funding: YES (internship gratification if applicable)

Unsupervised learning of temporal sequences in spiking networks with STDP

Keywords: statistical physics, neuroscience, learning, neural networks, plasticity

One of the most amazing features of neuronal systems is their capability to learn, i.e., to change their activity patterns as a function of experienced inputs. A major goal of neuroscience is to understand how learning is implemented in the brain, and huge progress has been made both theoretically and experimentally over the last decades. Notably, associative neural networks have been proposed as possible substrates of memory, and synaptic plasticity rules consistent with forming associative memories have been discovered. However, important questions as to the implementation of learning algorithms in cortical networks remain: While models typically consider only stationary inputs, external stimuli like moving visual scenes or sound exhibit temporal structure. How does Hebbian learning generalize to temporally structured inputs? Which learning rules allow to acquire stable neural representations of temporal patterns? In our lab, we plan to address these questions by combining computational approaches and experiments, focussing on the emergence of neural representations of sounds in the auditory cortex of mice. More precisely, we propose, and aim to test, a novel hypothesis about how spike-timing dependent plasticity (STDP) of cortical neurons provides a natural way of creating and/or recruiting neuronal ensembles that become increasingly co-active at the repeated presentation of temporally structured inputs. The internship will cover theoretical aspects and involve both analytical calculations as well as simulations of spiking neural networks and analysis thereof. Ample opportunity for interaction with experimentalists in the team will exist.

Requirements: solid knowledge in statistical physics, genuine interest in neuroscience, basic programming skills in Python