Master de Sciences et Technologies
Mention Biologie Intégrative et Physiologie
Parcours : Neurosciences
Responsable : Professeur Régis Lambert

Internship Proposal
Academic Year 2019-2020

1. Host team :

Research Unit (e.g. Department or Institute) : **ISIR (Institute of Intelligent Systems and Robotics)**
Research Unit Director : **Guillaume Morel**
Research Team Director : **Benoit Girard**
Team name : **AMAC (Architectures and Models for Adaptation and Cognition)**
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2. Internship project title:

Neural trajectory modeling by synaptic plasticity of the STDP type in the cerebral cortex in the asynchronous activity characteristic of the waking state

3. Internship Description :

State of the art. Many neural functions are based on action potential discharges organized into sequences in neurons of recurrent networks of the cortex. These sequences can underlie the representation of explicit trajectories in real spaces (navigation[1], motor execution[2]), or in more abstract spaces (perception[3], cognitive functions[4]). These neural trajectories represent a form of ordered local activity. However, they operate in the waking state within an asynchronous global activity, whose chaotic dynamics are disordered. How can such - functional and stable - neural trajectories be learned within this disordered asynchronous activity? Several recent models provide partial elements to understand this apparent contradiction. On the one hand, in a non-chaotic regime, time-dependent synaptic plasticity of action potentials (STDP) can, by phosphorylating the state of synaptic channel-receptors, carve out connectivity-oriented "paths" within recurrent networks[5], favoring the emergence of neural trajectories[6]. On the other hand, robust trajectories can emerge in the chaotic regime, but this has only been shown using biologically realistic learning rules[7].

Objective and approach. The team has recently shown that it is possible to learn trajectories in chaotic mode thanks to the synaptic STDP rule. However, these results were obtained by an "offline" procedure, that is artificially dissociating two phases. On the one hand, a preliminary learning phase (without neuronal activity), which aims at modifying the synaptic structure of the network. On the other hand, a simulation phase of network activity (this time without learning). This simulation phase aims at estimating the role of the synaptic structure learned during the learning phase (i) in the emergence of the spontaneous dynamic regime and (ii) in the ability to evoke neural trajectories. The aim of the internship is to mimic the real conditions for learning neural sequences in awaken mammals, considering an "online" procedure, in which the activity of the network and the synaptic learning take place simultaneously.

Working tasks. The internship work will aim, in the presence of STDP, excitatory and inhibitory synapses online[8], at evaluating trajectories learning and the effect of the chaotic activity on trajectories in three conditions, namely 1) in the absence of any stimulus, 2) in response to a transient stimulus (as found in learning relay-race working memory activities in the PFC[9]) and 3) in response to a trajectory stimulus. This work will include the following aspects: bibliographic research, programming under Matlab, model exploration, results analysis.

References

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