Département de CHIMIE ENS

Séminaire du Département de Chimie

INSTITUT PIERRE-GILLES DE GENNES
Pour la microfluidique

Biomimetic Neural Network for the new generation of neuroprothesis

Timothée LEVI
University of Bordeaux, IMS Lab., 33400 Talence, France

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Abstract: Millions of people worldwide are affected by neurological disorders which disrupt connections between brain and body causing paralysis or affect cognitive capabilities. Such a number is likely to increase in the next years and current assistive technology is still limited. Since last decades Brain-Machine Interfaces (BMIs) and generally neuroprosthesis have been object of extensive research and may represent a valid treatment for such disabilities. The realization of such prostheses implies that we know how to interact with neuronal cell assemblies, taking into account the intrinsic spontaneous activity of neuronal networks and understanding how to drive them into a desired state or to produce a specific behavior. The long-term goal of replacing damaged brain areas with artificial devices also requires the development of Spiking Neural Network (SNN) system. They will fit with the recorded electrophysiological patterns and will produce in their turn the correct stimulation patterns for the brain so as to recover the desired function. Our study describes the development of neuromorphic devices containing biomimetic neural networks.

Two designs are described, one using digital silicon neurons, and the other using microfluidic neurons, which is a new way to explore in neuromorphic engineering :

Firstly, the digital SNN, we will describe, implements biologically realistic neural network models, spanning from the electrophysiological properties of one single neuron up to network plasticity rules. This digital implementation computes in real-time biologically realistic cortical Izhikevich neurons and it requires few resources. The interneuron connections are composed of biomimetic synapses and synaptic plasticity. It is freely configurable from an independent-neuron configuration to different neural network configurations. This SNN will be used for the development of a neuromorphic chip for neuroprosthesis, which has to replace or mimic the functionality of a damaged part of the central nervous system.

Secondly, a new approach which is not yet in the state of the art is the design of biomimetic artificial neuron using microfluidic techniques. This microfluidic device is able to mimic the electrical activity of one biological neuron. Usually these artificial neurons are made in Silicon but this device could replace the electronic one and solve most of the issues of biocompatibility. This microfluidic device is composed of two chambers for intra and extra-cellular modelling, different PDMS channels, selective permeable membrane for positive ionic exchange, quake valves and electrodes for recording the membrane potential. We obtain an electrical membrane potential similar to the biological neuron.

Contact : jacques.fattaccioli@ens.fr (especially if you wish to discuss with our guest)