LABORATORY OF COMPUTATIONAL NEUROSCIENCE (LCN)

Prof. Wulfram Gerstner
EPFL – IC & SV– LCN
SG –AAB119 (Bâtiment SG-AAB)
Station 15
CH - 1015 LAUSANNE, Switzerland

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Thursday, September 18th, 2014
13h30, Room AAC 132

Computational Neuroscience Seminar

Raoul-Martin MEMMESHEIMER,

Faculty of Science, Neuroinformatics,
Radboud University Nijmegen, Netherlands

Learning precisely timed spikes

Experiments have revealed precisely timed patterns of spikes in several neuronal systems, raising the possibility that these temporal signals are used by the brain to encode and transmit sensory information. It is thus important to understand the capability of neural circuits to learn to produce stimulus specific temporally precise spikes. Learning to spike at given times is challenging since the spike threshold and the ensuing reset induce a strongly nonlinear dependence of the voltage on the value of the synaptic weights. I will present two learning algorithms, High Threshold Projection and Finite Precision Learning that accomplish the task. High Threshold Projection Learning converges in finite time to exactly fit the desired spike pattern if it is realizable. First Error Learning is a more biologically plausible rule, which converges to solutions with finite precision. The algorithms are employed to establish the capacity of a leaky integrate-and-fire neuron using a temporal code. We use theoretical considerations to derive the scaling of the capacity and to predict its numerical value in the low output rate regime. To show that our algorithms are able to learn behaviorally meaningful tasks from real neuronal data, we apply them to neuronal recordings of song birds. In addition, this proposes a novel way to estimate the information content carried by spike patterns which is accessible to neuronal architectures. Further, we show that our approach may provide a simple method to reconstruct anatomical connectivity from spike trains. Finally, we generalize our learning algorithms to perform learning of precise spike timing patterns in arbitrary neuronal architecture that includes feedback and recurrent connections.

Reference: Memmesheimer, R-M, Rubin* R, Ölveczky BP, Sompolinsky H, "Learning Precisely Timed Spikes",Neuron 82:925-938 (2014).*