Gilson et al. BMC Neuroscience 2010, 11(Suppl 1):P191
http://www.biomedcentral.com/1471-2202/11/S1/P191

BMC Neuroscience

POSTER PRESENTATION Open Access

The representation of input correlation structure from multiple pools in the synaptic weights by STDP

Matthieu Gilson[1,2,3], Anthony N Burkitt[1,2*], David B Grayden[1,2], Doreen A Thomas[1,3], J Leo van Hemmen[4]

From Nineteenth Annual Computational Neuroscience Meeting: CNS*2010
San Antonio, TX, USA. 24-30 July 2010

Spike-timing-dependent plasticity (STDP) has been shown to generate a synaptic weight structure by the strengthening (potentiation) or weakening (depression) of synapses depending on the timing of the pre- and post-synaptic spikes at the synapse at the scale of milliseconds [1,2]. Mathematical studies of STDP have shown how it generates competition between individual weights that can lead to effective neuronal specialization relying on spike-time correlations [3,4]. In addition, the change in the synaptic weight induced by STDP is affected by its current value, which modulates the resulting competition [5]. It was shown for the case of a single neuron stimulated by two identical input pools that the asymptotic weight distribution can be either unimodal or bimodal, depending on the strength of the weight dependence for STDP [6]; the transition (bifurcation) between these two classes of STDP also depends upon the input correlation level. Stronger input correlations and almost-additive STDP lead to effective weight specialization, namely an asymptotic bimodal distribution. For the case of several pools with identical properties, the weight dependence can also lead to the selection of a subset of the pools [7].

In this paper it is shown under what conditions a neuron stimulated by several pools that have within-pool (but no between-pool) correlations with distinct strengths encodes this input structure in its resulting weight structure. The analysis is carried out using the Poisson neuron model [3] with pair-wise weight-dependent STDP [6]. The learning dynamics induced by STDP leads to both stabilization of the input weights and competition between the weights for a broad range of learning parameters. While weak weight dependence is synonymous with strong competition between individual weights, there is a qualitative difference between the weight dynamics generated by additive and almost-additive STDP. For additive STDP, only the bounds of the weights are stable, whereas intermediate values can be stable even for weakly weight-dependent STDP. In the latter case, a stable multimodal asymptotic distribution can emerge, where the weights are sorted in increasing order with respect to the correlation strength of the corresponding pool they come from. When the strength of weight dependence is increased, the spreading of the asymptotic distribution diminishes, eventually becoming unimodal.

The results demonstrate how weakly weight-dependent STDP can generate a multimodal stable asymptotic distribution of the synaptic weights, providing a further step towards a better understanding of how STDP can represent the input (spike-time correlation) structure in the resulting weight structure.

Acknowledgements
This work was funded partly by NICTA, The Bionic Ear Institute, the Australian Research Council (ARC Discovery Projects #DP0771815 and #DP1096699) and BCCN-Munich.

Author details
[1]Department of Electrical and Electronic Engineering, University of Melbourne, Melbourne, VIC 3010, Australia. [2]The Bionic Ear Institute, East Melbourne, VIC 3002, Australia. [3]NICTA, Victoria Research Lab, University of Melbourne, Melbourne, VIC 3010, Australia. [4]Physik Department (T35) and BCCN-Munich, Universität München, 85747 Garching bei München, Germany.

Published: 20 July 2010

References
1. Gerstner W, Kempter R, van Hemmen JL, Wagner H: **A neuronal learning rule for sub-millisecond temporal coding.** *Nature* 1996, **383(6595)**:76-78.

* Correspondence: aburkitt@unimelb.edu.au
[1]Department of Electrical and Electronic Engineering, University of Melbourne, Melbourne, VIC 3010, Australia

2. Markram H, Lübke J, Frotscher M, Roth A, Sakmann B: **Physiology and anatomy of synaptic connections between thick tufted pyramidal neurones in the developing rat neocortex.** *J Physiol* 1997, **500**:409-440.
3. Kempter R, Gerstner W, van Hemmen JL: **Hebbian learning and spiking neurons.** *Phys Rev E* 1999, **59(4)**:4498-4514.
4. Song S, Miller KD, Abbott LF: **Competitive Hebbian learning through spike-timing-dependent synaptic plasticity.** *Nature Neurosci* 2000, **3**:919-926.
5. Bi GQ, Poo MM: **Synaptic modifications in cultured hippocampal neurons: Dependence on spike timing, synaptic strength, and postsynaptic cell type.** *J Neurosci* 1998, **18**:10464-10472.
6. Gütig R, Aharonov R, Rotter S, Sompolinsky H: **Learning input correlations through nonlinear temporally asymmetric Hebbian plasticity.** *J Neurosci* 2003, **23(9)**:3697-3714.
7. Meffin H, Besson J, Burkitt AN, Grayden DB: **Learning the structure of correlated synaptic subgroups using stable and competitive spike-timing-dependent plasticity.** *Phys Rev E* 2006, **73**:041911.

doi:10.1186/1471-2202-11-S1-P191
Cite this article as: Gilson *et al.*: The representation of input correlation structure from multiple pools in the synaptic weights by STDP. *BMC Neuroscience* 2010 **11**(Suppl 1):P191.