Synaptic Learning: Induction, maintenance and consolidation of synaptic connections.

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Abstract

Changes in the connection strength between neurons in response to appropriate stimulation are thought to be the physiological basis for learning and memory formation. Long-Term-Potentiation (LTP) and Long-Term-Depression (LTD) of synapses in cortical areas have been the focus in the research of acquisition and storing new information. LTP can be induced at groups of synapses by strong 'tetanic' high-frequency stimulation of the presynaptic pathway while stimulation at lower frequency leads to LTD. This principle has led to the computational learning-rule (BCM), which can capture the properties of synaptic LTP and LTD for single neurons and also replicate certain experimental protocols.

However, while the induction protocol for LTP and LTD is often as short as a few seconds, the changes in synaptic efficiency persist for much longer. For an understanding of the transition from early to late LTP, the concept of 'synaptic tagging and capture' has become influential. During induction of the early phase of synaptic change strong cellular activation puts a marker on the specific synapse, that induces later maintenance.

Clopath et al. (2008) have developed a computational model that takes those maintenance properties into account and they were able to reproduce specific LTP and LTD protocols that last for several hours. Using our model for learning V1-like receptive fields out of natural scenes (Wiltschut & Hamker, 2009) we used the major ideas from this homeostatic approach and expanded our model with this features. We developed a Calcium-based learning rule of synaptic change that accounts for homeostatic and self-regulating mechanism as well as maintenance and consolidation of synaptic strength.

This talk will show the basic principles of homeostatic synaptic learning and will show some experimental results and the results of Clopath et al. This presentation will also compare and discuss preliminary results of our extended model.

References:

[1] Clopath C, Ziegler L, Vasilaki E, Büsing L, Gerstner W (2008) Tag-Trigger-Consolidation: A Model of Early and Late Long-Term-Potentiation and Depression. PLoS Comput Biol 4(12): e1000248

[2] Wiltschut J, Hamker F (2009) Efficient Coding correlates with spatial frequency tuning in a model of V1 receptive field organization. Visual Neuroscience. 26:21-34