Developing an example of symmetric spike-timing dependent plasticity in NEST

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1 Outline

1.1 Project idea

We aim to replicate the main results from the seminal paper by Vogels et al., "Inhibitory Plasticity Balances Excitation and Inhibition in Sensory Pathways and Memory Networks" (Science, 2011).

This influential work demonstrates that a simple Hebbian plasticity rule applied to inhibitory synapses can lead to a robust, self-organized balance between excitation and inhibition. Remarkably, this balance emerges without fine-tuning and accounts for a wide range of experimental observations.

Our objective is to reproduce the key figures from the original study while simultaneously developing a concrete example implementation in NEST. Although the Vogels inhibitory plasticity rule is already implemented in NEST, no reference example is currently provided. Our work will therefore both validate the original findings and contribute a practical, reusable example for the community.

1.2 Rationale

The main rationale of this proposal is to deepen our knowledge of NEST as a simulation tool, while also extending our understanding of a synaptic plasticity mechanism that was not covered during the school. In addition, if successful, this work will allow us to make a small but meaningful contribution to the NEST community.

1.3 Background

As we aim to reproduce an existing study, our main reference will be the Vogels et al. paper, together with its extensive supplementary material (including MATLAB and NEURON code), as well as the NEST documentation. We will also rely on the collective experience of our group, which brings together diverse backgrounds that complement each other well.

1.4 Methods

Everything structural in the paper (IF neurons, conductance synapses, Poisson inputs, large recurrent networks, assemblies via weight scaling, external stimulation, spike recording) is standard NEST. The core learning mechanism proposed in the paper is already implemented. Also, the exeternal drive can be done using the inhomogeneous Poisson generator to create the spike trains.

1.5 Expected outcomes

By the end of summer school, we expect to be able to reproduce at least the two main figures of the paper and to develop a solid NEST example implementing the Vogels inhibitory synaptic plasticity rule.