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1 Overview

This report summarizes the behavior and control of two different astrocyte models. These models were designed with activity modulation in mind, where the astrocyte receives an input, which is integrated over time. This temporal integration results in an output or "effect" which is meant to be beneficial to the overall system.

2 Models

2.1 Target Average Firing Rate

This model consists a state update function and parameters, along with an effect function and parameters. The driving equations evaluated at each time step with length dt.

Astrocyte State Update $s = s + z * \alpha_s - s * \tau * dt$

Astrocyte Effect Computation $eff = \alpha_e * (target - s)$

In this case the Astrocyte acts as a proportional controller, providing feedback at the post-synaptic (pre-lif) connection. The magnitude of the effect, is proportional to the difference between a target, and the astrocyte state value. The overall goal of this behavior is to regulate high levels of neuron activity and suppress periodic activity beyond the target rate. Whether this has a computational benefit it remains to be seen.

2.2 Average Rate Suppression

In this model the astrocyte uses the exponentially weighted average of its inputs as the state variable. During the effect computation, an additional multiplier is applied (must be negative for suppression) to the state, and applied as the effect.

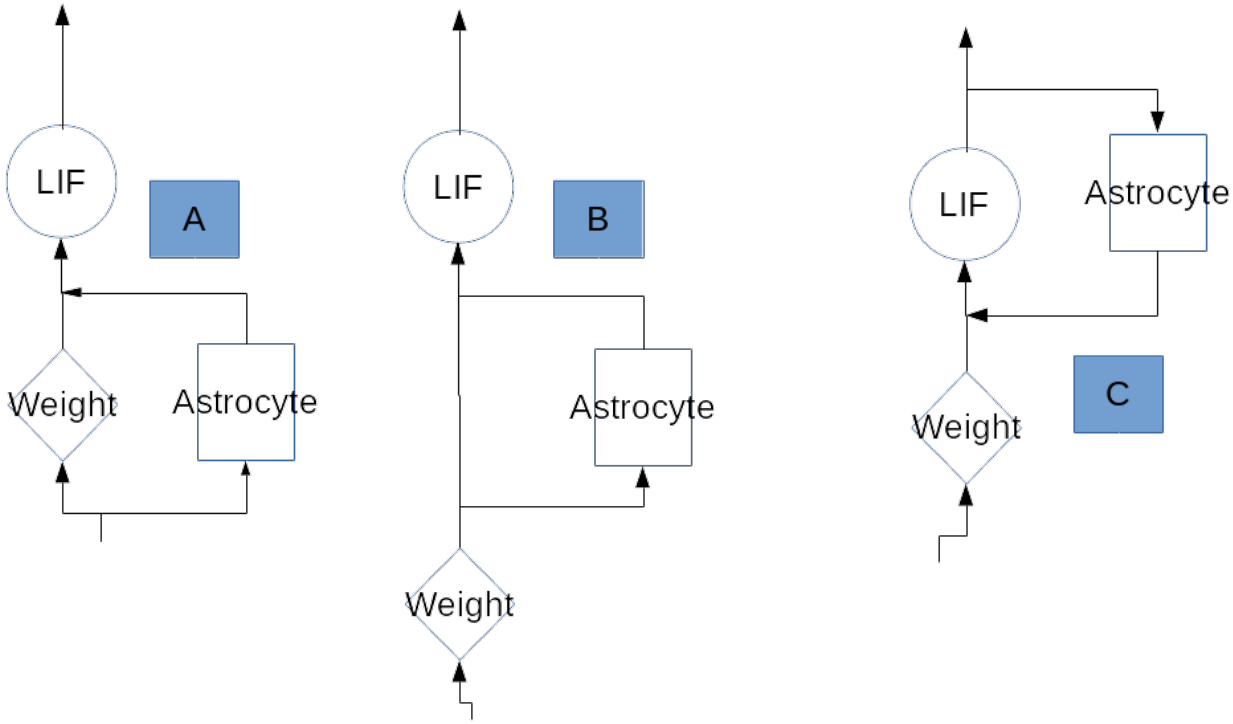
Astrocyte State Update $s = s * (1.0 - \alpha) + z * \alpha$

Astrocyte Effect Computation $eff = \alpha * s$

The goal in this case is to implement synapse-level habituation based on the activity in a population of synapses. Such a control element might be able to tune a population of synapse, or neurons to maximize contrast while ignoring periodic noisy input.

3 Topology

A few topologies are used across the two models



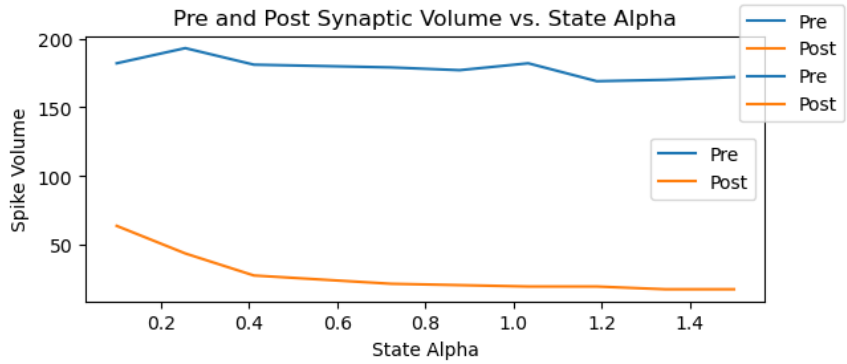
4 Simulations

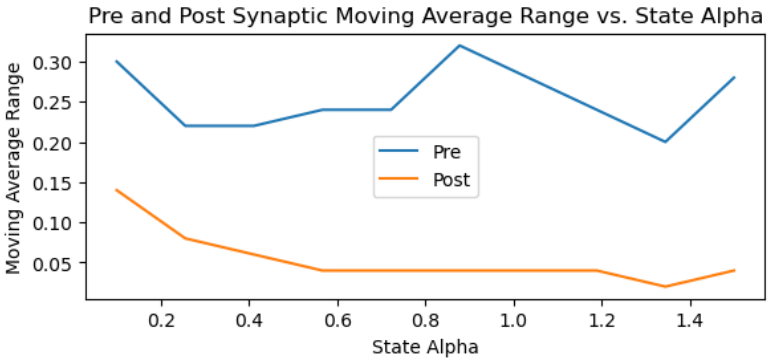
4.1 Target Average Firing Rate

There are a few basic properties of this model that are intuitive, and supported by simulation.

4.1.1 State Sensitivity

α_s can be thought of as the state sensitivity, since it controls how much an input spike (or potential) contributes to the state in that time step. In general, a lower sensitivity will reduce the Astrocyte's ability to respond to activity, allowing more of the pre-synaptic information through.





Author: Jacob Kiggins
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