Automated point-neuron simplification of data-driven microcircuit models

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Abstract:

A method is presented for the reduction of morphologically detailed microcircuit models to a point-neuron representation without human intervention. The simplification occurs in a modular workflow, in the neighborhood of a user specified network activity state for the reference model, the "operating point". First, synapses are moved to the soma, correcting for dendritic filtering by low-pass filtering the delivered synaptic current. Filter parameters are computed numerically and independently for inhibitory and excitatory input on the basal and apical dendrites, respectively, in a distance dependent and post-synaptic m-type specific manner. Next, point-neuron models for each neuron in the microcircuit are fit to their respective morphologically detailed counterparts. Here, generalized integrate-and-fire point neuron models are used, leveraging a recently published fitting toolbox. The fits are constrained by currents and voltages computed in the morphologically detailed partner neurons with soma corrected synapses at three depolarizations about the user specified operating point. The result is a simplified circuit which is well constrained by the reference circuit, and can be continuously updated as the latter iteratively integrates new data. The modularity of the approach makes it applicable also for other point-neuron and synapse models.

The approach is demonstrated on a recently reported reconstruction of a neocortical microcircuit around an in vivo-like working point. The resulting simplified network model is benchmarked to the reference morphologically detailed microcircuit model for a range of simulated network protocols. The simplified network is found to be slightly more sub-critical than the reference, with otherwise good agreement for both quantitative and qualitative validations.

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