Compartmental models with user-defined trans-membrane currents through NESTML

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Neurons in the brain are characterized by their elaborate dendritic trees and varied distributions of trans-membrane currents [1]. In previous work, we extended NEST with the capability to simulate compartmental models [2]. While the dendritic layout could be defined at runtime, ion channel and synaptic receptor dynamics could not be customized. Here, we address this shortcoming by leveraging NESTML: trans-membrane currents can be written intuitively as equations, which are combined with the previously implemented integrator for compartmental dynamics and compiled.

All trans-membrane currents in a given neuron model are written down in a single NESTML file, either as ion channels or as receptor currents. The compartmental layout is defined at run-time, while optionally specifying the ion channel parameters declared in NESTML. Finally, synaptic receptors are added, again while optionally specifying receptor parameters.

In contrast to other compartmental simulators [3], we have chosen a low-level interface for the compartmental models in NEST, where the parameters of individual compartments are exposed. Thus, users can easily define few-compartment models with abstract dendritic subunits. Additionally, NEAT (Neural Analysis Toolkit) provides a high-level interface to export both detailed and simplified dendritic models [5] to NEST. With these additions, NEST becomes an attractive tool for the simulation of micro-, meso- and massive-scale networks of neurons with dendritic trees.

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