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Stochastic neuron model implementation in NEST using NESTML

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Neurons exhibit intrinsic sources of stochasticity which impact on their spiking behavior. These sources include fluctuations in ion channel gating and diffusion, as well as stochastic release of neurotransmitters. As a result, even when responding to identical inputs, there can be significant variability in spike timing.
The Galves–Löcherbach (GL) model [1] is a stochastic neuron model that was proposed to capture the effect of these sources of intrinsic noise on neuronal spiking activity. It models the neuron as a stochastic point process with spiking probability that depends on its membrane potential. After a spike, the neuron's membrane potential is instantaneously reset to 0.
In this work, we present an implementation of the GL model in NEST simulator [2] using the domain specific language NESTML [3]. Additionally, we implemented a version with short-term plasticity dependent on residual calcium [4]. In this case, when a neuron spikes the residual calcium concentration within the cell increases by one unit, and a postsynaptic potential is given that depends linearly on the spiking neuron's calcium concentration. Between successive spikes, the membrane potential and calcium concentration of the neuron decrease at a constant rate.
Further simulations are necessary to validate the proof of concept implementation with respect to theory and detailed benchmarking and optimisation. On the theoretical side the NESTML specification facilitates the comparison to other stochastic neuron models. The implementation of the GL model in NEST will provide researchers with a powerful tool for investigating the large-scale spiking neural networks dynamics in an efficient manner.

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Topic area

models and applications

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