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A simplified model of NMDA-receptor-mediated dynamics in leaky integrate-and-fire neurons

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A model for NMDA-receptor-mediated synaptic currents generating persistent activity proposed by Wang and Brunel [1-3] has been widely adopted in computational neuroscience, both for spiking-neuron and mean-field models [1-4]. The model describes synaptic dynamics by a phenomenological two-dimensional nonlinear ODE system for the gating variable S(t). Due to the nonlinearity, the pre-synaptic gating variables of a post-synaptic neuron cannot be simulated in aggregated form. Numerically efficient solutions are only feasible for fully connected networks with identical, short delays (see e.g. [5]).

We derive a linear approximation to Wang's model which allows us to integrate all NMDA input currents to a neuron in aggregate form as for linear synapses. Using a reference implementation in NEST, we show that the approximation is accurate and that a network model based on the approximation shows the same decision making dynamics as one using Wang's original model. For an example network with around 8000 neurons, the approximation is about 30 times faster, and scales sublinearly with the number of synapses.

Exploiting the flexibility and performance gained through the approximation, we investigate the dynamics of a binary decision-making network with sparse connectivity and randomized delays.

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Speaker time zone

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