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Revisiting time discretisation of spiking network models

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A link is built between a biologically plausible generalized integrate and fire (GIF) neuron model with conductance-based dynamics [1] and a discrete time neural network model with spiking neurons [2], for which rigorous results on the spontaneous dynamics has been obtained. More precisely the following has been shown.

i) Occurrence of periodic orbits is the generic regime of activity, with a bounded period in the presence of spike-time dependence plasticity, and arbitrary large periods at the edge of chaos (such regime is indistinguishable from chaos in numerical experiments, explaining what is obtained in [2]),

ii) the dynamics of membrane potential has a one to one correspondence with sequences of spikes patterns ("raster plots").

This allows a better insight into the possible neural coding in such a network and provides a deep understanding, at the network level, of the system behavior. Moreover, though the dynamics is generically periodic, it has a weak form of initial conditions sensitivity due to the presence

Figure 1
A view of the numerical experiments software platform raster-plot output, considering either a generic fully connected network or, here, a retinotopic network related to visual functions (top-left: 2D instantaneous spiking activity).

of the sharp spiking threshold [3]. A step further, constructive conditions are derived, allowing to properly implement visual functions on such networks [4].

The time discretisation has been carefully conducted avoiding usual bias induced by e.g. Euler methods and taking into account a rather complex GIF model for which the usual arbitrary discontinuities are discussed in detail. The effects of the discretisation approximation have been analytically and experimentally analyzed, in detail.

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