DYNAMIC MEAN-FIELD PREDICTIONS FOR INTERACTING EXCITATORY AND INHIBITORY POPULATIONS OF SPIKING NEURONS

M. Mattia, P. Del Giudice
Physics Lab., Italian Nat. Inst. of Health
Roma, Italy
http://neural.iss.infn.it

ABSTRACT

We extend the mean-field approach to the dynamics of populations of spiking neurons introduced in [1], to the multi-population case. In particular, in view of the phenomenological interest of balanced networks of excitatory and inhibitory neurons, we examine the case of two interacting populations of excitatory and inhibitory neurons, and compare theoretical predictions with simulation data. For the two populations, we specifically examine the relaxation times of the collective activity when reacting to a perturbation from an asynchronous state; we also study the power spectrum of the collective activity in a stationary asynchronous state. We focus on the way the characteristic times and the spectral properties depend on the relative strength of the stochastic and deterministic components of the input current to the neurons: in a *drift-dominated* regime, where the fluctuation in the afferent current are a small correction to the deterministic part, the transient regime involves damped oscillations, and most of the energy in the power spectrum is concentrated around multiples of the population spike emission rate; in a *noise-dominated* regime, where fluctuation dominate the afferent currents, the system exponentially relaxes after perturbation, and prominent peaks in the power spectrum are at high frequencies determined by the transmission delays.

Synaptic efficacies between neurons, and the finite number of neurons, are crucial ingredients of the analysis: the former (together with the delays) turns out to determine the stability of the network, and the high frequency part of the power spectrum, while the latter, with the associated finite-size fluctuations, can be formally described as generating an ‘internal’ white noise (whose power in turn depends on the activity of the network), which effectively ‘stimulates’ the frequency response properties of the system (in the linear approximation) in a huge frequency range, even in the absence of oscillating external inputs.

We discuss how, in appropriate limits on the intra- and inter-populations connectivity, the dynamic mean-field predictions for the coupled populations boil down to the description of either one, sensing the other as an external input.

Keywords: Spiking neurons, dynamic mean-field theory, recurrent networks

References

[1] Mattia M., Del Giudice P. (2002) Population dynamics of interacting spiking neurons. *Phys. Rev. E* **66**:051917.