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The perturbation response and power spectrum of a mean-field of IF neurons with inhomogeneous inputs

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The aim of this study is to construct a bottom-up model of cortical dynamics that is capable of describing the same types of neural phenomena as top-down continuum models, namely the power spectrum, frequency response to perturbation and EEG time-series. The key difference between the two approaches is that the bottom-up approach preserves more of the intrinsic physiological details than the top-down models [1]. A stochastic Fokker-Planck modelling approach is used to describe a network of leak integrate-and-fire (IF) neurons with temporally inhomogeneous inputs. Previous work either calculated the response of a single neuron with conductance-based synapses, or the network with current-based synapses [2]. In this study we use and extend a recently published Fokker-Planck approach [3] within an analytical framework to calculate the dynamical firing-rate of a network with conductance-based synapses receiving temporally inhomogeneous synaptic input. In particular, the network has fully recurrent connectivity with both the steady-state and the dynamic perturbation response of the background activity fed back into the inputs. This is done in a self-consistent formalism [4] for a network of excitatory and inhibitory neurons.

The Fokker-Planck formalism enables the calculation of the linear response of the firing-rate to perturbation with recurrent connections. The power spectrum and EEG time-series of the network are calculated by treating the synaptic inputs as an inhomogeneous Poisson process. From this we determine the auto-correlation function, which is identified as a cyclo-stationary process. The signal is then phase-averaged over its period and the Wiener-Khinchin theorem is used to determine the power spectrum from the autocorrelation function. The power spectrum is convolved with a filter to approximate the local field potential propagation through the extra-cellular fluid [5].

The analytical results of the frequency response of the dynamical firing rate and its power spectra are compared with numerical simulation results for a recurrently connected network with conductance-based synapses and temporally inhomogeneous inputs. Results are obtained using parameter values that represent typical cortical *in vivo* neurons [4]. This work is the first stage necessary for constructing a physiologically plausible mathematical model of a mesoscopic network of cortical columns.

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References

1. Suffczynski P, Wendling F, Bellanger JJ, Da Silva FHL: **Some insights into computational models of (patho) physiological brain activity.** *Proceedings of the IEEE* 2006, **94(4)**:784-804.
2. Burkitt AN: **A review of the integrate-and-fire neuron model: II. Inhomogeneous synaptic input and network properties.** *Biol Cybern* 2006, **95**:97-112.

3. Richardson MJE: **Spike-train spectra and network response functions for non-linear integrate-and-fire neurons.** *Biological Cybernetics* 2008, **99(4)**:381-392.
4. Brunel N: **Dynamics of sparsely connected networks of excitatory and inhibitory spiking neurons.** *J Comput Neurosci* 2000, **8**:183-208.
5. Bedard C, Destexhe A: **Macroscopic models of local field potentials and the apparent 1/f noise in brain activity.** *Biophys J* 2009, **96**:2589-2603.

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