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Microcircuits of stochastic neurons

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Multiplicatively interacting point processes and applications to neural modelling Stefano Cardanobile & Stefan Rotter BCCN Mathematical analysis of complex neural network dynamics is both challenging and important for research in neuroscience. current approaches, though, rely on mean-field approximations, which have difficulties to evalutate the influence of networ structure on its spiking dynamics. We exploit the stochastic nature of neuronal firing and set up a point process framework, the observation that the escape noise of real neurons is exponential with respect to their membrane voltage [1]. Assuming li integration of inputs, this translates into a multiplicative interaction rule on the level of instantaneous firing rates: each inco spike effectively multiplies the instantaneous firing rate by a fixed "synaptic weight". This approach is in contrast to Hawkes model [2], where the instantaneous firing rate is given by a convolution of the input spike rate with a linear temporal filter. effectively prevents the implementation of inhibition in this model. We proved that the equations governing the dynamics o expected firing rates in our multiplicative system are of Lotka-Volterra type, if one ignores covariances [3]. Based on numer simulations, we show that this approximation works quite well under very general conditions. Asymptotically, the observed rates coincide with the solutions of the associated rate equations even in cases where the rates do not converge to a fixed po exhibit transient dynamics. Multiplicatively interacting point processes offer an interesting novel framework for the study o neural network dynamics. To illustrate this claim, we finally describe some structured networks that are able to process info and discuss specifically competing neural populations to describe experiments where rivaling features are perceived. Our m qualitatively replicates the unimodal distribution of dwell times as observed in experiments, and it leads to an intuitive expl the switching dynamics. The project has been supported by BMBF grant 01GQ0420 to the BCCN Freiburg.

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EVENT ABSTRACT » Ba

Beyond linear perturbation theory: the instantaneous response of integrate-and-fire model

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The integrate-and-fire neuron model with exponential postsynaptic potentials is widely used in analytical work and in simu studies of neural networks alike. For Gaussian white noise input currents, the membrane potential distribution is known ex The linear response properties of the model have successfully been calculated and applied to the dynamics of recurrent net this diffusion limit [2]. However, the diffusion approximation assumes the effect of each synapse on the membrane potenti infinitesimally small. Here we present a novel hybrid theory that takes finite synaptic weights into account. We show, that t considerably alters the absorbing boundary condition at the threshold: the probability density increases just below thresho result, the response of the neuron to a fast transient input is enhanced much in the same way as found for the case of synap filtering [3]. However, in contrast to this earlier work relying on linear perturbation theory [4], we quantify to all orders an instantaneous response that is asymmetric for excitatory and inhibitory transients and exhibits a non-linear dependence on perturbation amplitudes. Furthermore we demonstrate that in the pooled response of two neuronal populations to antisym transients the linear components exactly cancel. In this scenario the macroscopic network dynamics is dominated by the instantaneous non-linear components of the response. These results suggest that the linear response approach neglects imp features of the rectifying nature of threshold units with finite jumps even for small perturbations. We provide an analytical framework to go beyond [5]. Partially funded by BMBF Grant 01GQ0420 to BCCN Freiburg, EU Grant 15879 (FACETS), DI Helmholtz Alliance on Systems Biology, and Next-Generation Supercomputer Project of MEXT.

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