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Poster presentation

Spatial organization of evoked neuronal dynamics in 2D recurrent networks, with or without structured stimulation

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Neuronal dynamics in the awake mammalian cortex are known to display highly irregular spiking activity and asynchronous firing patterns at the population level (AI regime). Many computational models have proposed simplified benchmarks to investigate information propagation in such regimes [1]. However, to allow explicit analytical analysis, most of them assume random connectivity within the network, no propagation delays and unstructured Poisson external input [2]. In particular, for AI regimes, these models do not exhibit any substantial spatial correlations [3]. In contrast, in biological V1, it has been observed that the large-scale dynamics produced by ongoing reverberation correspond to spatially structured activity maps characterized by distance-dependent correlations [4,5]. A realistic model of sensory neocortex should thus take into account the presence of intrinsic spatial correlation in order to study how this may interfere with structured correlation evoked by the sensory drive.

We have simulated sparsely connected networks of conductance-based integrate-and-fire neurons with Gaussian spatial connectivity profiles. We systematically computed the distant-dependent correlations at the extracellular (spiking) and intracellular (membrane potential) levels between randomly assigned pairs of neurons. These networks exhibit AI states with cross-correlation functions decreasing exponentially with inter-neuronal distance.

Our results show that the typical decay constant of spatial spread for spontaneous correlation is affected by the underlying extent of connectivity (the Gaussian variance) as well as by the ongoing network state. However, this correlation length can only be modulated for network states displaying emergent synchronous firing. In particular, for AI regimes, the spontaneous spatial correlation length does not depend on the extent of intrinsic connectivity. Next, we considered the case of a topologically organized input layer feeding feedforward input streams with a fixed Gaussian divergence. We measured the dependence of the evoked modulation in correlation length on the ratio between the relative spread (divergence) of the input and of the recurrent intracortical connectivity.

When balanced input is fed into the network through excitatory and inhibitory external inputs, the correlation length is strongly reduced (compared to the ongoing state) independent of the external input spread. In contrast, purely excitatory input triggers transient lateral propagating waves whose lifetime depends on the external input spread. The dynamical state following this transient exhibits a larger correlation length. Therefore, the correlation structures found in the macroscopic activation patterns are strongly affected both by the intrinsic dynamical state and by the divergence of the external drive.

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