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Synchronization and rate dynamics in embedded synfire chains: effect of network heterogeneity and feedback

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The synfire chain has been proposed as a network model to understand the origin of recurring spatio-temporal spike patterns observed in cortical in-vivo activity [1]. Under transient [2] or persistent stimulation [3], synfire chains can form synchronous volleys of spikes ("pulse packets") that stably propagate through the network. We have shown previously [3] that the spiking dynamics in synfire chains, the existence and stability of asynchronous and synchronous states, can be well understood in the framework of a stationary population-rate model. Here, we demonstrate that both the effect of feedback to an embedding background network and the effect of network heterogeneity (e.g., heterogeneity in the number of inputs per neuron [in-degree]) can be incorporated in this theory. By this means, we show that functionally relevant, i.e., bistable, parameter regimes are mainly determined by rate instabilities and not by the stability of oscillatory modes of the embedding background network [4]. Moreover, this study illustrates that (even stationary) population-rate models can be valuable tools to describe synchronization phenomena on a millisecond time scale. See figure 1.

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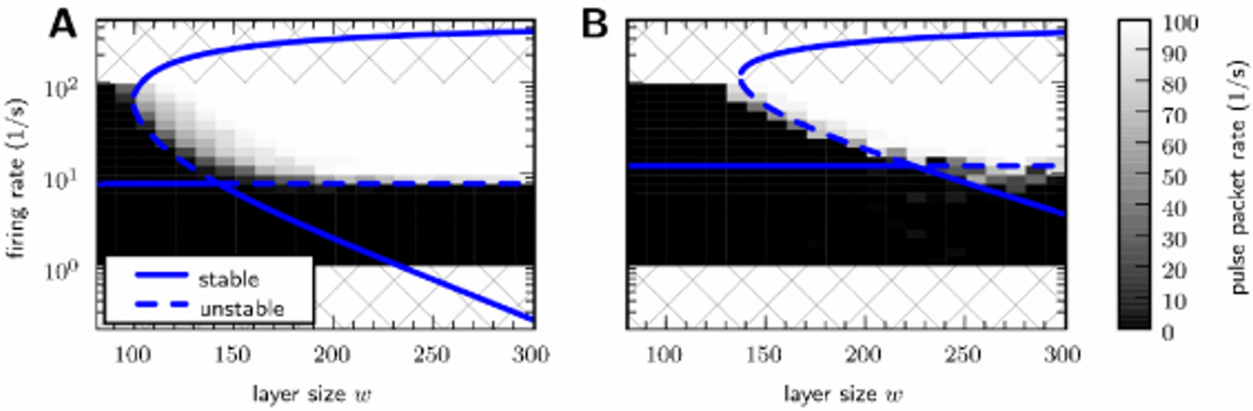

Figure 1

Rate dynamics and synchronization in a synfire chain. Pulse-packet rate (gray coded) measured in the 10th layer as function of the layer size w and the rate perturbation (log scale) applied to the first layer (simulation results). Stable (solid lines) and unstable fixed points (dashed) of the corresponding population-rate model are superimposed. A: constant in-degree. B: uniformly distributed in-degrees. Hatched areas represent parameter regimes in which no simulations were performed.