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POSTER PRESENTATION

Modeling persistent temporal patterns in dissociated cortical cultures using reservoir computing

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Persistent spatiotemporal patterns have been observed extensively in various neural systems including cortical cultures [1]. Activity in cortical cultures is composed of network-wide bursts of spikes, during which global firing rate increases dramatically. Previously, it has been shown that cultures display persistent temporal patterns that are hierarchically organized and stable over several hours. Fluctuations in the culture activity persistently converge to stable precise temporal patterns, for which these patterns are called dynamic attractors. Temporal structure in network bursts can be clustered into several groups, each of which can be seen as a separate burst type.

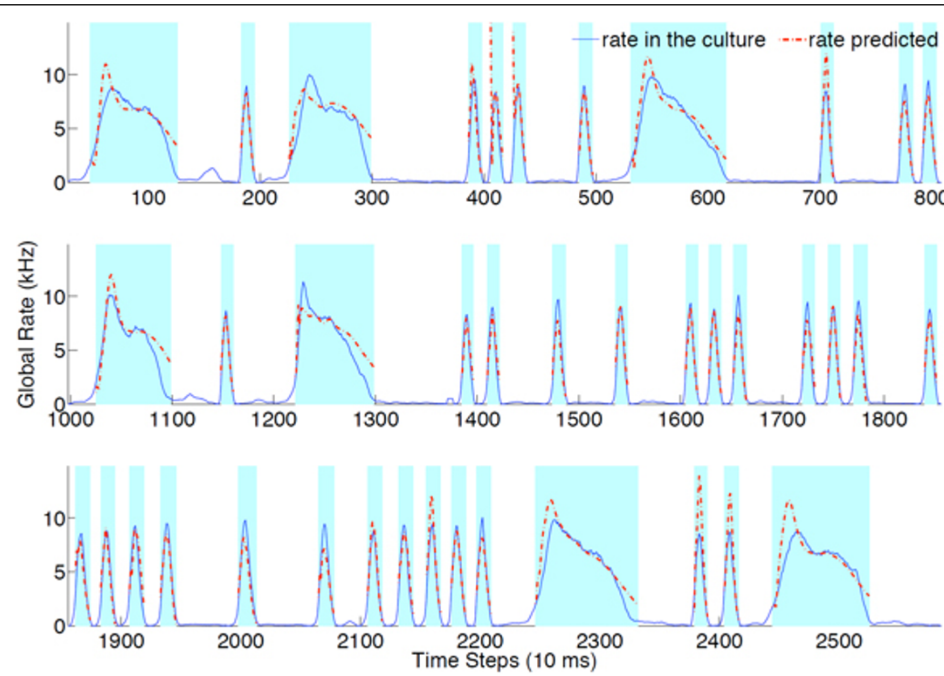

Figure 1 Comparison of the observed firing rate (solid, blue) and the predicted firing rate (dashed, red) in a selected culture. Light blue shaded regions in the background indicate the intervals, where prediction is done based on the cue signal. The cue signal is the spatial pattern containing the firing rates of all electrodes just 1 time step before the shaded region. The overall correlation coefficient between the predicted and the observed signal is 0.88.

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A model of a neural system should be able to reproduce the temporal patterns under the same input and/or initial state, which is a minimal requirement for a network-level model to reveal the information encoded in such patterns. Our approach taken here is to employ a generic model (a reservoir network) that displays a rich repertoire of complex spatiotemporal patterns to be matched with the observed biological patterns by parameter tuning. More specifically, we employ an Echo State Network (ESN) [2] with leaky integrator neurons as a modeling tool. Here, we consider cultures of dissociated cortical tissue recorded with microelectrode arrays (MEA) as an example of biological neural networks without specific connectivity and simulate the corresponding burst types based on a cue signal. The cue signal is composed of a snapshot (10 ms) of the individual firing rates recorded at each electrode at burst onset and serves as an indicator of the current dynamic state of the network. A simple readout training of the ESN yields a predictive model of the temporal activity pattern in the global firing rate. The simulated pattern displays a high correlation with the actual one observed in the culture (Figure 1). The model can also be used to visualize the underlying structure in the recorded signals.

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