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Information transmission between recurrent neural networks by sparsely electrical connections

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The dynamical states and the spatio-temporal patterns in balanced recurrent neural networks are considered a key element for the understanding of biological information processing and memory. The monitoring of many individual neurons has become feasible with the technical development of multi-electrodes arrays. However, for practical use of those arrays as bidirectional neuro-interfaces, feedback signals have to be generated in real-time to integrate the electrodes into the existing spatio-temporal context as a new information source. A recent idea is the generation of feedback signals by an artificial neural network with similar dynamic properties as the biological one. The artificial network will pre-process electrode signals and generate adequate feedback signals for the biological network. The artificial network is more transparent for advanced methods to analyse synchronous firing patterns and reacts more stably to external input signals.

In a preliminary modelling study we connected two artificial recurrent networks by few channels that approximate the connections of the multi-electrode arrays. We use a biological plausible model based on Ihzikevich et al. and adapt the parameters to fit the dynamics of cortical networks developing in cell culture. The resulting topological and dynamical properties of the combined networks were analysed for the free running system. External input signals are approximated by the stimulation of one network with specific spatial patterns (additional current sources to selected neurons), which influences the dynamics of both networks. The information transmission between the networks is quantified by the classification of patterns from the dynamics of the non-stimulated network, and correlated with the number and the spatial topology of the used connections.

The adaptation of artificial networks to real biological networks was tested by offline training with data recorded from cultured biological networks. To establish a recurrent connection to biological networks, the artificial network and all data pre-processing has to operate in a real time environment. The requisites are currently under development in our lab.