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Robust design of inhibitory neuronal networks displaying rhythmic activity

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Abstract: Central pattern generators are neuronal circuits which autonomously produce patterns of phase-locked activity. The need for bioelectronic implants that adapt to physiological feedback calls for novel methods for designing synthetic CPGs that respond identically to their biological counterparts. Nonlinearity within such networks make both the prediction of network behaviour and, inversely, the design of networks with desired behaviour non-trivial. Here, we demonstrate the utility of optimization-based data assimilation for identifying sets of synaptic and intrinsic parameters which give rise to network activity with specific temporal properties. We reduce the dimension of the problem by visualizing the behaviour of N-cell networks in a coordinate system composed of the (N-1) relative phases of the oscillators. Transient network dynamics are represented by trajectories which converge towards fixed point attractors corresponding to stable rhythms. By considering the phase response curves (PRCs) of the component neurons we use D.A. to estimate parameters corresponding to desired attractor locations. Recent work has employed D.A. to optimize single neuron models. Reducing the dynamics to the cell PRCs allows us to estimate parameters of networks of arbitrarily complex neuron models without incurring prohibitive computational costs. We highlight a possible application of our approach by estimating parameters of a CPG which emulates the phase-locked activity associated with ECG data, paving the way for the design of synthetic networks which may be interfaced with nervous systems.

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