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The Role of Sparsity in Inverse Problems for Networks with Nonlinear Dynamics.

Sparsity is a fundamental characteristic of numerous biological, social, and technological networks. Network connectivity frequently demonstrates sparsity on multiple spatial scales and network inputs may also possess sparse representations in appropriate domains. In this work, we address the role of sparsity in solving inverse problems in networks with nonlinear and time-evolving dynamics. In the context of pulse-coupled integrate-and-fire networks, we demonstrate that nonlinear network dynamics imparts a compressive coding of both network connectivity and inputs provided they possess a sparse structure. Driving the network with a small ensemble of random inputs, we derive a mean-field set of underdetermined linear systems relating the network inputs to the corresponding activity of the nodes via the feed-forward connectivity matrix. In reconstructing the network connections, we utilize compressive sensing theory, which facilitates the recovery of sparse solutions to such underdetermined linear systems. This framework underlines the central role of sparsity in information transmission through network dynamics, providing new insight into the structure-function relationship for high-dimensional networks with nonlinear dynamics. (Received September 21, 2018)