Reconstructing Complex Networks from Noisy Dynamics

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Abstract:

The study of networks has emerged in many branches of science. Many systems of interest consist of a large number of components that interact with each other. These systems can be represented as networks with the individual components being the nodes or vertices and the interactions between two nodes being the links or edges that join the nodes. The overall behavior of the systems depends crucially on the network structure depicting how the nodes are linked with each other. The network structure is thus a crucial piece of information for us to understand the behavior and function of the system that the network represents. It is often difficult to directly measure the network structure while the dynamics of individual nodes can be measured with relative ease. For most systems of interest, the links are directional in that one node affects the dynamics of another node but its own dynamics is unaffected by the latter. These systems are represented as directed networks with directional links. In general, the strength of interaction can be different so the links have different weights. Reconstructing general directed and weighted networks from dynamics is a great challenge in network research. In this talk, we will discuss our work on addressing this challenge. Our approach is to focus on networks that attain a steady state in the absence of noise and derive mathematical relations relating the network structure and measurable quantities in the weak-noise limit. Using our approach, we have developed a method that can reconstruct the links and their weights for weighted networks with bidirectional diffusive-like coupling, and a method that can reconstruct the links and their directions for directed and weighted networks. For the latter method, we can further reconstruct the weights of the links when the coupling functions have certain additional properties. Using numerically simulated data, we have demonstrated that our methods give accurate results with low error rates for various networks with nonlinear dynamics and coupling functions.

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