Compressive sensing based prediction of complex dynamics and complex networks

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Abstract

In the fields of complex dynamics and complex networks, the reverse engineering, systems identification, or inverse problem is generally regarded as hard and extremely challenging mathematically as complex dynamical systems and networks consists of a large number of interacting units. However, our ideas based on compressive sensing, in combination with innovative approaches, generates a new paradigm that offers the possibility to address the fundamental inverse problem in complex dynamics and networks. In particular, in this talk, I will argue that evolutionary games model a common type of interactions in a variety of complex, networked, natural systems and social systems. Given such a system, uncovering the interacting structure of the underlying network is key to understanding its collective dynamics. Based on compressive sensing, we develop an efficient approach to reconstructing complex networks under game-based interactions from small amounts of data. The method is validated by using a variety of model networks and by conducting an actual experiment to reconstruct a social network. While most existing methods in this area assume oscillator networks that generate continuous-time data, our work successfully demonstrates that the extremely challenging problem of reverse engineering of complex networks can also be addressed even when the underlying dynamical processes are governed by realistic, evolutionary-game type of interactions in discrete time. I will also touch on the issue of detecting hidden nodes, on how to ascertain its existence and its location in the network, this being highly relevant to metabolic networks.

Keywords: compressive sensing, complex dynamics, complex networks, social network, reverse engineering

References

[1] Data based identification and prediction of nonlinear and complex dynamical systems, W.-X. Wang, Y.-C. Lai, and C. Grebogi, Phys. Reports 644, 1-76 (2016)

[2] Predicting catastrophe in nonlinear dynamical systems by compressive sensing, W.-X. Wang, R. Yang, Y.-C. Lai, V. Kovanis, and C. Grebogi, Phys. Rev. Lett. 106, 154101 (2011)

[3] Network reconstruction based on evolutionary-game data via compressive sensing, W.-X. Wang, Y.-C. Lai, C. Grebogi, and J. Ye, Phys. Rev. X 1, 021021 (2011)

[4] Forecasting the future: Is it possible for adiabatically time-varying nonlinear dynamical systems? R. Yang, Y.-C. Lai, and C. Grebogi, Chaos 22, 033119 (2012)

[5] Optimizing controllability of complex networks by minimum structural perturbations, W.-X. Wang, X. Ni, Y.-C. Lai, and C. Grebogi, Phys. Rev. E 85, 026115 (2012)