MAR14-2013-020513
Abstract for an Invited Paper
for the MAR14 Meeting of
the American Physical Society

Efficient discovery of large-scale patterns in weighted networks

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Networks provide a rich and mathematically principled approach to characterizing the structure of complex systems. A common step in understanding the structure and function of real-world networks is to characterize their large-scale organizational pattern via community detection, in which we aim to find a network partition that groups together vertices with similar connectivity patterns. Although interactions in most real-world systems take real or integer valued weights, common approaches to community detection use only the unweighted edges, thereby ignoring a potentially rich source of additional information. In this talk, I will describe a generalization of the popular stochastic block model that can discover community structure from both the existence and weight of edges. This model can be efficiently fitted to real-world networks using "approximate inference" techniques, like the cavity method, originally developed in statistical physics and which are now commonly used by computer scientists in machine learning. Applied to several real-world networks, I show that edge weights sometimes contain hidden information that is distinct from what is contained in edge existences. Learning from weights also provides better estimates of missing information. I will close with a few brief comments on the impact of weight information on the detectability threshold for recovering hidden patterns in these systems, and on future opportunities in this area.