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Spectral methods and Network Communities[1]

MIGUEL A. MUÑOZ, Universidad de Granada (Spain)

Spectral methods provide us with a powerful tool-box to explore the topology of networks. In this presentation we will review an application of spectral techniques to the analysis of communities in complex networks. Communities are network sub-groups formed by highly interconnected nodes, which are sparsely connected to the rest of the network. They appear ubiquitously in natural and artificial nets, and are believed to play a key role as functional units, and detecting them has become a crucial problem in complex-system analyses. The efficient and relatively fast algorithm we will present here exploits spectral properties of some matrices encoding the network topology (as the Laplacian matrix), combined with standard hierarchical-clustering techniques, and the use of the "modularity parameter" allowing to quantify the goodness of any possible community subdivision. The algorithm performance, will be compared with that of other existing methods, as applied to different well-known examples of artificial and real networks. Our results are in all the tested cases, at least as good as the best ones obtained with any other methods, and faster in most of the cases than methods providing similar-quality results. This converts the algorithm in a valuable computational tool for detecting and analyzing communities and modular structures in complex networks. The connection of these results with the problem of determining the optimal network topology to achieve synchronization within the net and to optimize other dynamical processes will also be put forward.

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