Consistent Community Detection for Complex Multilayer Networks under Near-Optimal Sparsity Conditions

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Abstract: During the last few decades, the prevalence of complex multi-layer and multiplex network data sets has increased significantly across many disciplines. In this article, we consider the problem of identifying the common community structure for multilayer network data. We propose two community recovery algorithms for multilayer network data based on spectral clustering of a judiciously pruned sum of squared adjacency matrices. For input networks generated from multilayer versions of the stochastic block models (MSBM) or the degree-corrected block models (MDCBM), we obtain a lower bound for the community detectability threshold (in the minimax sense) involving the model parameters. We provide theoretical guarantees that the proposed methods concede only a vanishing mis-clustering rate when the model parameters of the input network generated from MSBM or MDCBM satisfy a near-optimal condition, including the scenarios where (a) the community structures of individual layers are below the community detectability threshold, (b) the assortativity patterns of the community structure are unknown and vary arbitrarily across different layers, and (c) the input network is highly sparse (maximum expected degree of a node across all layers is below 1). We also reinforce the validity of the theoretical results and demonstrate the superiority of our algorithms over some of the existing methods via simulations.

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