Structural Analysis of Laplacian Spectral Properties with Application to Electric Transmission Networks

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The spectrum of the Laplacian matrix of a network plays a key role in a wide range of dynamical problems associated with the network, from transient stability analysis of power networks to distributed control of formations. Using methods from algebraic graph theory and convex optimization, we study the relationship between structural features of a network and spectral properties of its Laplacian matrix. We illustrate our results by studying the influence of structural properties on the Laplacian eigenvalues of the American (western states), French and Spanish high-voltage transmission networks. Our study suggests that for such networks the Laplacian spectral radii and spectral moments are strongly constrained by a particular set of local structural features, namely the degree sequence and the so-called joint-degree distribution. On the other hand, other structural properties that may seem important, such as the distribution of cycles in the network, appear to have a very weak influence on the Laplacian spectrum of electrical transmission networks. We also show that local structural features are not enough to characterize the Laplacian spectral gap. Therefore, since the spectral gap is fundamental in the analysis of many dynamical processes on networks, random models in which only local structural features are prescribed are typically insufficient to generate synthetic topologies in which these dynamical processes can be studied.

Comments:	Associated data and software can be found at this http URL
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