ID de Contribution: **7** Type: **Invited talk**

Extracting Hidden Hierarchies in Weighted Distribution Networks

mercredi 10 juin 2015 14:30 (45 minutes)

Natural and man-made transport webs are frequently dominated by dense sets of nested cycles. The architecture of these networks, as defined by the topology and edge weights, determines how efficiently the networks perform their function. Yet, the set of tools that can characterize such a weighted cycle-rich architecture in a physically relevant, mathematically compact way is sparse. In order to fill this void, we have developed an algorithm that hierarchically decomposes (filters) the graph and characterizes the graph based on the decomposition process. The algorithm starts by identifying a physically meaningful tiling of the network, proceeds to sequentially remove the weakest links as determined by the edge weight, merge neighboring plaquettes and and finally produces a tree characterizing this merging process. The properties of this characteristic tree can provide the physical and topological data required to describe the architecture of the network and to build physical models. We show how this new algorithm can be used for automated phenotypic characterization of 2D and 3D weighted networks the structure of which is dominated by cycles, such as the vasculature of leaves and complex transportation webs.

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