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Multilevel Backbone Extraction Based on the Network Component Structure

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As networks grow, reducing computational complexity while retaining relevant information becomes critical. Backbone extraction simplifies networks by filtering out non-critical edges and nodes [1]. This paper introduces a framework for backbone extraction, focusing on the mesoscopic structure. The proposed framework relies on the network component structure [2,3]. It consists of several steps:

1. Extract Dense Subgraph: Identify dense regions within the network.
2. Extract Local Components: Identify local components within the dense subgraph.
3. Extract Global Components: Identify global components, focusing on inter-community links.
4. Backbone Extraction for Local and Global Components: Apply a classical backbone extraction method.
5. Combine Backbones: Merge the local and global backbones to form the final Multilevel Backbone.

The study uses datasets from various domains, including social, ecological, technological, and transportation networks. Networks of different sizes are analyzed to ensure broad applicability. The performance of the Multilevel Backbone is compared with the Classical Backbone using metrics like weight distribution, degree distribution, and mesoscopic properties. The Multilevel Backbone approach significantly improves preserving the network's mesoscopic structure compared to the Classical Backbone.

Key findings include:

1. Better preservation of weight and degree distributions.
2. Improved performance in terms of modularity, participation coefficient, and inter-community connectivity, particularly in larger networks.
3. Enhanced performance in maintaining the heterogeneity of the original network.

Future research will explore heterogeneous mesoscopic backbone extraction techniques [4]

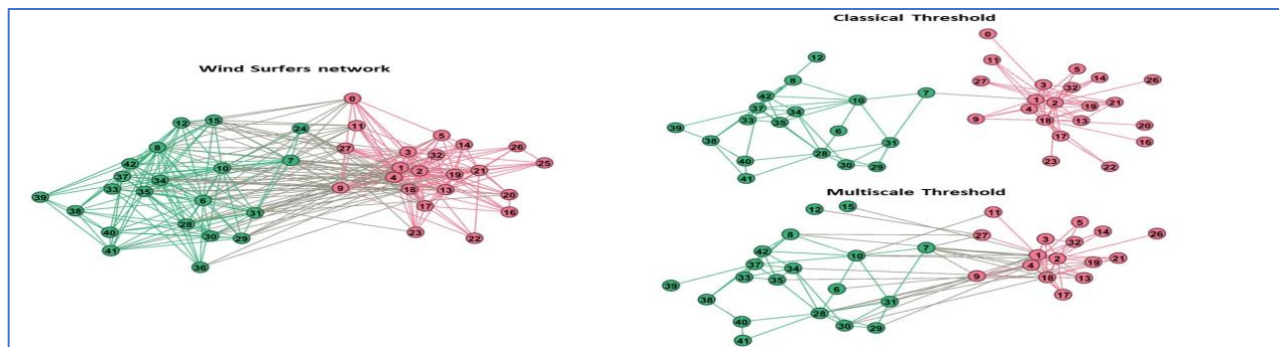


Figure 1 – The extracted backbones using Global Threshold of the 'Wind Surfers' network (43 nodes and 336 edges), with a fraction of edges fixed at 30%.

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- [3] Issa Moussa Diop, Cherif Diallo, Chantal Cherifi, Hocine Cherifi, " Exploring the Regional Structure of the Worldwide Air Traffic and Route Networks", *Complexity*, vol. 2023, Article ID 3411799, 29 pages, 2023. <https://doi.org/10.1155/2023/3411799>.
- [4] Rajeh, S., Savonnet, M., Leclercq, E. et al. Comparative evaluation of community-aware centrality measures. *Qual Quant* 57, 1273–1302 (2023). <https://doi.org/10.1007/s11135-022-01416-7>