Local and global solutions to community detection – when resolution matters –

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Community structure occurs at all scales, but an effective limit in resolution arises in commonly used community detection algorithms. This problem manifests itself in two distinct ways: relevant stand-alone structures are either *merged* with neighboring communities due to the inability of resolving small communities, or are entirely *ignored*, being overshadowed by larger or denser communities. The first aspect of this resolution limit stems from the assumption that global parameters are sufficient to determine a varying structure uniformly across the network [1]. We explore solutions to this problem in the form of new local community definitions that rely on an optimization framework based on spectral methods. Since objective functions lie at the core of this framework, we are able to quantify our findings precisely. The second aspect of the resolution limit is related to the hierarchical nature of community structure. We propose a global solution, based on the observation that if detection is done sequentially, cascading through the organizational layers of the network, it is possible to detect previously ignored structures [2]. We conclude by discussing the strength and weaknesses of both the local and global approaches.

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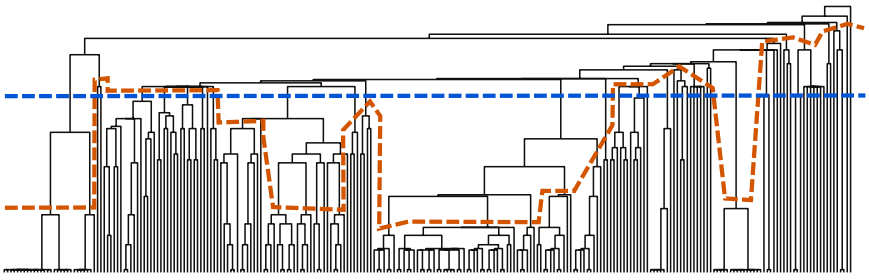
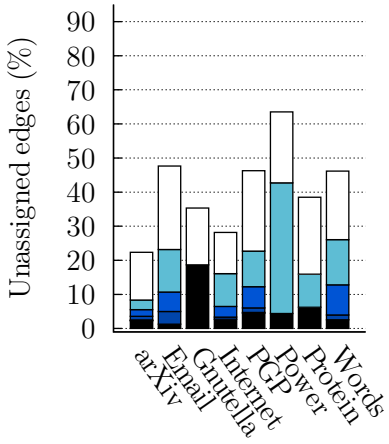
[1] Ronhovde, P., and Nussinov, Z., Local resolution-limit-free Potts model for community detection. *Phys. Rev. E*, 81:046114, 2010.

[2] Young, J.-G., Allard, A., Hébert-Dufresne, L., and Dubé, L.J., Unveiling Hidden Communities Through Cascading Detection on Network Structures, arXiv:1211.1364, 2012. To appear in Springer's Lecture Notes in Computer Science.

[3] Ahn, Y.-Y., Bagrow, J. P., and Lehmann, S., Link Communities Reveal Multiscale Complexity in Networks. *Nature*, 466:761, 2010.



(a) **Local approach:** Ahn *et al*'s link clustering algorithm (LCA) [3] involves a global optimization of the density that does not allows variation of the resolution across the network, yielding a stiff cut of the community dendrogram (blue line). By locally optimizing the community structure, we effectively allows variation in the resolution (skeched orange line).



(b) **Global approach:** Iterations of the LCA, applied to 8 different networks, reduces the number of unassigned edges (from white to black) as each iteration further reveals the underlying structure.