DETECTING STRONG COMMUNITIES FROM COOPERATIVE GAMES

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In a cooperative game with transferable utility, players can choose to form different coalitions that generate different amounts of values. The problem is often to find an imputation in the core that allows the grand coalition to form. In this work, we propose a new problem of identifying strong communities in the cooperative game and show how the solution can be applied to cluster directed weighted graphs.

We formulate the problem with a measure that not only tells whether a coalition can be formed but also how strong the coalition is. The measure can be interpreted as the amount of support a community can guarantee to give to any of its members when they are in need. Such need-based community support is not a fair payment and is therefore not captured by the well-known Shapley value, nucleolus, and egalitarian solution. The community support is also different from the value of the least core and the cost of stability because the latter quantities are meaningful when the grand coalition cannot be formed apriori, i.e., the core is empty, but the community support is even when the core is non-empty.

Unlike many community detection formulations where the exact solutions are often non-unique and NP-hard to compute, our formulation for convex games leads to a unique hierarchy of successively stronger communities that can be represented efficiently by a dendrogram. In particular, the dendrogram can be computed in polynomial time using submodular function optimization techniques. Furthermore, the solution can reduce to a new hierarchical clustering method for weighted digraphs, in which case the computation can be more efficient using a max-flow algorithm. Compared with other algorithms, simple examples show that our method can return more natural clusters. Preliminary experimental results on real-world dataset show that our algorithm can return more densest subgraphs. Results on LFR benchmark also reveals that existing methods fail to return large communities of large strength.

- GitHub repository: https://github.com/ccha23/info-game-clustering