Contribution ID: **94** Type: **not specified**

Expander Decomposition with Fewer Inter-Cluster Edges Using a Spectral Cut Player

Thursday, July 13, 2023 11:20 AM (20 minutes)

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Abstract: A (ϕ, ϵ)-expander-decomposition of a graph G (with n vertices and m edges) is a partition of V into clusters $V_1, \ldots, V_k$ with conductance $\Phi(G[V_i]) \geq \phi$, such that there are at most ϵm inter-cluster edges. Such a decomposition plays a crucial role in many graph algorithms. We give a randomized $\tilde{O}(m/\phi)$ time algorithm for computing a $(\phi, \phi \log^2 n)$-expander decomposition. This improves upon the $(\phi, \phi \log^3 n)$-expander decomposition also obtained in $\tilde{O}(m/\phi)$ time by [Saranurak and Wang, SODA 2019] (SW) and brings the number of inter-cluster edges within logarithmic factor of optimal.

One crucial component of SW's algorithm is non-stop version of the cut-matching game of [Khandekar, Rao, Vazirani, JACM 2009] (KRV):The cut player does not stop when it gets from the matching player an unbalanced sparse cut, but continues to play on a trimmed part of the large side. The crux of our improvement is the design of a non-stop version of the cleverer cut player of [Orecchia, Schulman, Vazirani, Vishnoi, STOC 2008] (OSVV)). The cut player of OSSV uses a more sophisticated random walk, a subtle potential function, and spectral arguments. Designing and analysing a non-stop version of this game was an explicit open question asked by SW.

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Session Classification: Track A-4