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Minimum Cuts and Shortest Homologous Cycles

We describe the first algorithms to compute minimum cuts in surface-embedded graphs in near-linear time. Given an undirected graph embedded on an orientable surface of genus g, with two specified vertices s and t, our algorithm computes a minimum (s, t)-cut in $g^{O(g)}\, n \log n$ time. Except for the special case of planar graphs, for which $O(n \log n)$-time algorithms have been known for more than 20 years, the best previous time bounds for finding minimum cuts in embedded graphs follow from algorithms for general sparse graphs. A slight generalization of our minimum-cut algorithm computes a minimum-cost subgraph in every Z_2-homology class. We also prove that finding a minimum-cost subgraph homologous to a single input cycle is NP-hard.