On Finding Optimal Polytrees

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Inferring probabilistic networks from data is a notoriously difficult task. Under various goodness-of-fit measures, finding an optimal network is NP-hard, even if restricted to polytrees of bounded in-degree. Polynomial-time algorithms are known only for rare special cases, perhaps most notably for branchings, that is, polytrees in which the in-degree of every node is at most one. Here, we study the complexity of finding an optimal polytree that can be turned into a branching by deleting some number of arcs or nodes, treated as a parameter. We show that the problem can be solved via a matroid intersection formulation in polynomial time if the number of deleted arcs is bounded by a constant. The order of the polynomial time bound depends on this constant, hence the algorithm does not establish fixed-parameter tractability when parameterized by the number of deleted arcs. We show that a restricted version of the problem allows fixed-parameter tractability and hence scales well with the parameter. We contrast this positive result by showing that if we parameterize by the number of deleted nodes, a somewhat more powerful parameter, the problem is not fixed-parameter tractable, subject to a complexity-theoretic assumption.