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A dichotomy for succinct representations of homomorphisms

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Abstract: The task of computing homomorphisms between two finite relational structures A and B is a well-studied question with numerous applications. Since the set Hom(A,B) of all homomorphisms may be very large having a method of representing it in a succinct way, especially one which enables us to perform efficient enumeration and counting, could be extremely useful.

One simple yet powerful way of doing so is to decompose Hom(A,B) using union and Cartesian product. Such data structures, called d-representations, have been introduced by Olteanu and Zavodny in the context of database theory. Their results also imply that if the treewidth of the left-hand side structure A is bounded, then a d-representation of polynomial size can be found in polynomial time. We show that for structures of bounded arity this is optimal: if the treewidth is unbounded then there are instances where the size of any d-representation is superpolynomial. Along the way we develop tools for proving lower bounds on the size of d-representations, in particular we define a notion of reduction suitable for this context and prove an almost tight lower bound on the size of d-representations of all k-cliques in a graph.

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