Uncovering Hidden Structure through Parallel Problem Decomposition for the Set Basis Problem[*]

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Abstract

Exploiting parallelism is a key strategy for speeding up computation. However, on hard combinatorial problems, such a strategy has been surprisingly challenging due to the intricate variable interactions.

In this paper we introduce a novel way in which parallelism can be used to exploit hidden structure of hard combinatorial problems, orthogonal to divide-and-conquer and portfolio approaches. We demonstrate the success of this approach on the minimal set basis problem, which has a wide range of applications e.g., in optimization, machine learning, and system security. We also show the effectiveness of our approach on a related application problem from materials discovery.

In our approach, a large number of smaller sub-problems are identified and solved concurrently. We then aggregate the information from those solutions, and use this information to initialize the search of a global, complete solver. We show that this strategy leads to a significant speed-up over a sequential approach since the aggregated sub-problem solution information often provides key structural insights to the complete solver. Our approach also greatly outperforms state-of-the-art incomplete solvers in terms of solution quality. Our work opens up a novel angle for using parallelism to solve hard combinatorial problems.