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Hybrid approaches combining Metaheuristics and Mathematical Programming for 0-1 mixed integer programming

Abstract: The 0-1 mixed integer programming (0-1 MIP) problem consists of maximizing or minimizing a linear function subject to equality or inequality constraints and binary choice restrictions on some of the variables. Several special cases of the 0-1 MIP problem, such as knapsack, traveling salesman and routing problems, are known to be NP-hard. Branch-and-bound and branch-and-cut methods have long been considered the methods of choice for solving mixed integer programming problems. Many contributions have led to successive improvements in these methods. Metaheuristic methods have attracted attention as possible alternatives or supplements to the more classical approaches. The view adopted in this talk is that metaheuristic approaches can benefit from a change of perspective in order to perform at their best in the MIP setting. Recent adaptive memory and evolutionary metaheuristics for mixed integer programming have included proposals for introducing inequalities and target objectives to guide the search. These guidance approaches are useful in intensification and diversification strategies related to fixing subsets of variables at particular values, and in strategies that use linear programming to generate trial solutions whose variables are induced to receive integer values. Glover and Hanafi (2010) introduced procedures for generating target objectives and solutions by exploiting proximity in original space or projected space. In this talk, we will develop more advanced approaches for generating the target objective based on exploiting the mutually reinforcing notions of reaction and resistance. Model embedded memory, as proposed in parametric tabu search, will be integrated to provide a range of recency and frequency memory structures for achieving goals associated with short term and long term solution strategies. We propose supplementary linear programming models that exploit the new inequalities for intensification and diversification, and introduce additional inequalities from sets of elite solutions that enlarge the scope of these models. We have investigated the use of new relaxations in a general iterative scheme to solve 0-1 Mixed Integer Programming programs. In the first one, called MIP relaxation, we release the integrality constraints over only a part of the binary variables, rather than releasing these constraints over all the 0-1 variables like in the continuous relaxation. In the second one, called Iterative Semi-Continuous relaxation, the binary variables are forced to take values close to 0 or 1. These relaxations can be used to improve the upper bound of a maximization problem, but their efficiency (in term of computation time) depends on the desired accuracy, implying a weighting between performance and complexity. The corresponding approaches have been evaluated on variants of the knapsack problem, and the results have demonstrated their efficiency for solving large instances.

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