Machine Learning and optimization: an approach for real-world discrete problems

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Abstract.

Discrete optimization problems can be found in several applications and often are expensive to solve. Therefore, the necessity of heuristics that can quickly approximate the optimal solutions. In this setting, we propose a new and easy to apply framework using Machine Learning.

Our proposed method sets up a classifier that, given inputs features such as the solution to the continuous relaxation, the reduced costs, and other problem-specific information, estimates the value assumed by the variable in the optimal solution. Then, according to the size of the instance and the confidence computed by the classifier, a vast percentage of variables is fixed and the remaining part of the solution is computed by mean of an exact solver.

We trained the aforementioned model in a supervised manner, and we applied it to several variants of the the Knapsack problem mimicking resource allocation in real-world situations: these include the Robust Knapsack that considers a cost uncertainty, and the Quadratic Knapsack that takes into account the mutual benefits associated with tuples of items. Our contribution provides cheap computation time and close-to-optimal results, thus potentially opening up new perspectives in the application of operations research to real-world problems.

Keywords: Heuristics; Machine Learning; Discrete Optimization Problems;