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# Perturbed Decomposition Algorithm applied to the multi-objective Traveling Salesman Problem

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**Abstract**

Dealing with multi-objective combinatorial optimization, this article proposes a new multi-objective set-based meta-heuristic named Perturbed Decomposition Algorithm (PDA). Combining ideas from decomposition methods, local search and data perturbation, PDA provides a 2-phase modular framework for finding an approximation of the Pareto front. The first phase decomposes the search into a number of linearly aggregated problems of the original multi-objective problem. The second phase conducts an iterative process: aggregated problems are first perturbed then selected and optimized by an efficient single-objective local search solver. Resulting solutions will serve as a starting point of a multi-objective local search procedure, called Pareto Local Search. After presenting a literature review of meta-heuristics on the multi-objective symmetric Traveling Salesman Problem (TSP), we conduct experiments on several instances of the bi-objective and tri-objective TSP. The experiments show that our proposed algorithm outperforms the best current methods on this problem.

*Keywords:* Multi-objective combinatorial optimization, Multi-objective Traveling Salesman Problem, Meta-heuristics, Pareto Local search, Decomposition algorithm, Data perturbation

## 1. Introduction

In multi-objective (MO) combinatorial optimization, several criteria are taken into account. When the preferences of the decision maker are not known, a far challenge is to generate the set of non-dominated points, so that no improvement on any objective is possible without sacrificing on at least another objective. Even for moderately-sized problems, it is usually computationally prohibitive to identify this set for two major reasons. First, the decision version of most MO combinatorial optimization (MOCO) problems is $\mathcal{NP}$-complete, even if the underlying single-objective version is in $\mathcal{P}$. Second, most MOCO problems are intractable in the sense that the number of non-dominated points can be exponential in the size of the instance (see [1] for more details on MO optimization).

To handle these difficulties, researchers have been interested in developing heuristic algorithms, such as meta-heuristics. In particular, MO local search (LS) algorithms are among the most successful meta-heuristics for tackling MOCO problems. The currently best performing LS meta-heuristics for MOCO problems typically involve different algorithmic components that are combined into an upper-level framework.

This article presents the Perturbed Decomposition Algorithm (PDA) algorithm. The framework of PDA combines single-objective LS and MO LS techniques, MO decomposition [2] and data perturbation [3]. To validate our approach, we conduct experiments on several instances of the bi-objective and tri-objective symmetric Traveling Salesman Problem (MOTSP) of different types and sizes.

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