Configuring the Perturbation Operations of an Iterated Local Search Algorithm for Cross-domain Search: A Probabilistic Learning Approach

Publisher: IEEE

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Abstract:
Hyper-heuristics are general-purpose heuristic search methodologies for solving combinatorial optimization problems (COPs). Research findings have revealed that hyper-heuristics still suffer generalization issues as different strategies vary in performance from an instance of a COP to another. In this paper, an approach based on Iterated Local Search (ILS) is proposed to raise the level of generality of hyper-heuristics on the problem domains of the HyFlex framework. The proposed approach utilizes a probabilistic learning technique

to automatically configure the behavior of the ILS algorithm during the perturbation stage of the optimization process. In the proposed method, the mutation and ruin-recreate heuristics are treated as distinct entities and the learning layer automatically determines the level of utilization of these heuristic categories depending on the problem domain being solved. The concept of double shaking is also presented where a solution can be perturbed twice before the intensification phase. Experimental results reveal the level of generality achieved by the proposed method as it recorded a minimum formula one score of 30.0 on each tested problem domain. Direct comparison with a state-of-the-art ILS-based approach also establishes the significance of the learning layer added to the perturbation stage of the ILS metaheuristic. Finally, analysis of the perturbation behavior of the hyper-heuristic leads to an interesting conclusion concerning the type of low-level heuristics that are highly beneficial and non-beneficial to a given problem domain.

Published in: 2021 IEEE Congress on Evolutionary Computation (CEC)
Date of Conference: 28 June-1 July 2021
Date Added to IEEE *Xplore*: 09 August 2021
ISBN Information:
INSPEC Accession Number: 21074088
DOI: 10.1109/CEC45853.2021.9504841
Publisher: IEEE
Conference Location: Kraków, Poland
Funding Agency:

I. Introduction

Solving problems from multiple domains with a single methodical approach characterize hyper-heuristics research. Various forms of optimization problems have been solved using hyper-heuristics including; vehicle routing [1], travelling thief problem [2], bin packing [3], timetabling [4], scheduling [5], knapsack problem [6] and search-based software engineering [7]. Hyper-heuristics can be broadly categorized into generation and selection hyper-heuristics [8]. Selection hyper-heuristics is a class of hyper-heuristics [8] which have been receiving progressive contribution in the scientific research community in recent years, with invention of different approaches [9]. This study focuses on the selection hyper-heuristics, particularly the application of Iterated Local Search as hyper-heuristic solvers. The selection hyper-heuristics are typically equipped with two components: selection mechanism and acceptance mechanism for selecting low-level heuristics (LLHs) and accepting/rejecting the solutions produced by the selected LLHs respectively. In recent times, HyFlex (Hyper-heuristics Flexible framework) as a software framework designed to enable testing and comparison of iterative general-purpose heuristic search algorithms has been employed widely for testing new hyper-heuristic approaches by researchers [9]. The HyFlex framework [10] implemented six combinatorial optimization problems including Maximum Satisfiability (SAT), Bin Packing (BP), Personnel Scheduling (PS), Permutation Flow-shop (PFS), Travelling Salesman Problem (TSP), and Vehicle Routing Problem (VRP).

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