A Memetic Algorithm for the Orienteering Problem with Intermediate Facilities

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The Orienteering Problem with Intermediate facilities (OPIF) is a new variant of the orienteering problem. In this variant, the objective is to find a given number of connected trips while maximizing the sum of collected scores. OPIF has been introduced by us in a recent publication under the name of orienteering problem with hotel selection [5].

In the OPIF, a set of N vertices is given while each vertex is assigned a score S_i. There are H intermediate facilities available which don't have a score. The time needed to travel between each pair of vertices or intermediate facilities is given by t_{ij} ; the time available for each trip $d = 1, ..., D$ is a limited given time budget T_d. Each of the D connected trips starts and ends in one of the H intermediate facilities. Initial and final points (depots) of the whole tour can also be used as an intermediate facility during the tour.

Some examples of the large number of potential applications of OPIF are explained in [5] : a submarine performing a surveillance activity composed of consecutive missions, the design of a multi-day tourist trip through an attractive region or a traveling sales person who needs to select which of his possible clients to visit during his multiple day tour and also needs to choose the most appropriate hotels to stay every night.

In the literature, although there are some works considering intermediate facilities in node (and arc) routing problems with a cost (or time) minimizing objective function, there is no research on maximizing the total collected score together with selectivity the most appropriate intermediate facilities. Beside this main and important difference, in none of the problems in the literature, a time constraint is imposed on each trip length and also the fact that the initial and final depot are allowed to be used as an intermediate facility is not the case in any of these similar problems. Moreover, the number of connected trips in the tour in OPIF is a given parameter of our problem which makes it different from these reviewed problems [1,2,4].

The memetic algorithm (MA) is a combination of an evolutionary algorithm and local search (LS) techniques [7]. Memetic algorithms were introduced by Moscato [6] and have been successfully applied for VRPs by Prins [8]. Bouly et. al. [3] were first to propose a memetic algorithm for a variant of the OP, namely TOP. The general structure of the MA we propose to deal with the OPIF is a

genetic algorithm (GA) focusing mainly on optimising the intermediate facilities. There are also several local search moves embedded in a variable neighborhood structure to further improve the solution.

Our algorithm contains two major steps : Initialization and improvement. In the initialization part, an orienteering problem (OP) is heuristically solved between every possible pairs of intermediate facilities in each trip. A very fast and straightforward algorithm is used to solve OPs here. In this step, two matrices are created : One to save the solution between pairs of intermediate facilities and one to save the potential scores. Then, a number of feasible combinations of intermediate facilities are created and by applying the Local Search on each of these feasible combinations, the initial population is prepared. In the improvement phase two crossover and one mutation operators are developed to diversify the search space by creating different combinations of intermediate facilities. To ensure the variety of different possible combination of IFs, A Tabu List is used for recently selected hotels in each trip.

To verify the algorithm, we solved a number of benchmark instances [5]. The MA is applied on 158 instances of OPIF with various sizes from 5 to 15 intermediate facilities and 3 to 10 trips. The algorithm is run 3 times on each instance and the average and best results are considered. Comparing these results with our previous algorithm (VNS) [5] shows an improvement in both solution quality and computational time specially for larger instances with higher number of feasible combinations of intermediate facilities.

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