Quick-and-dirty Ant Colony Optimization

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Categories and Subject Descriptors: I.2.8 [Problem Solving, Control Methods, and Search]: Heuristic methods

General Terms: Algorithms, Experimentation.

Keywords: ant colony optimization, hybrid approach.

In this study, we focus on an hybridization of ACO and a local search heuristic. The two approaches work sequentially, and ant colony optimization is used for pointing out the region of the search space in which to start the local search. The bigger the problem instance to tackle, in general, the more important this point is for the quality of the solution achieved [2]. In this sense, ACO is in the service of the local search. We consider $\mathcal{MAX}$–$\mathcal{MIN}$ Ant System ($\mathcal{MM}$AS) [5] and a modified Lin-Kernighan Heuristic for the traveling salesman problem (LKH) [2]. We will call the hybrid algorithm as `quick-and-dirty ant colony optimization`. This denomination has been chosen for stressing the fact that ants are supposed not to converge on a very high quality solution, but to return quickly a fairly good one. This solution will be appropriate to the aim of the first part of `q&dACO` if the balance of exploration and exploitation allows ants to achieve a good understanding of the feasible region before converging toward a (possibly local) optimum [1, 4]. Moreover, the search space has to present the clusterization of the best solutions [3]. In this case, one can expect the solution returned by ACO to be in the basin of attraction of a local optimum which is *close* to the global one. The local search heuristic is then in charge of selecting the best optimum of the nearby region. This procedure, then, needs to be able to escape from the basin of attraction of an optimum solution to move to the basin of attraction of a different one. It needs to be, then, a quite sophisticated local search, as the modified Lin-Kernighan Heuristic.

A typical measure of the level of convergence of ant algorithms is the average λ-branching factor [1]. By using as stopping criterion for the algorithm this measure crossing a certain threshold *br*, the best solution found will belong to the area still under exploration – and then to the most promising region of the search space –. Then, `q&dACO` passes to a local search heuristic. The only characteristic that this approach needs to have, is the ability – to some extent – of escaping from local minima. Lin-Kernighan Heuristic for the traveling salesman problem [2] has this feature.

The experimental analysis proposed is based on the traveling salesman problem. We compare the results of `q&dACO`with those achieved by the LKH heuristic [2] started from random solutions, and with the ones achieved by an hybrid genetic algorithm. This second algorithm is based on the same idea considered for `q&dACO`, except that the initial phase is committed to a genetic algorithm. We consider four sets of instances of different size. In each run the search is restarted three times. Both the LKH and the GA-LKH heuristic are started each time with a different random seed. `q&dACO` is restarted each time considering a different value of *br*, the threshold for the average γ-branching factor which represents the stopping criterion for the first phase of `q&dACO`.

The results support our intuition: If the feasible region of the problem is such that the best solutions are clustered, as in the traveling salesman problem, starting the local search in the basin of attraction of a good local optimum, makes it likely to get closer and closer to the global one. In particular, the larger the instances, the better the performance achieved by `q&dACO` compared to LKH and to a hybrid genetic algorithm based on the same basic ideas.

Consisting in a metaheuristic and a local search procedure, the approach proposed may be easily applied to many combinatorial optimization problems. Object of future work will be the application of `q&dACO` to different problems. An interesting element that may be investigate is the relative importance of the two phases, when varying the problem tackled. For example, this relevance may vary in case of very constrained problems with respect to an unconstrained one. Moreover, various local search procedures may be tested. Different procedures, considering different neighborhoods, may get to very different results.

GECCO'07, July 7–11, 2007, London, England, United Kingdom.
ACM 978-1-59593-697-4/07/0007.

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