Discussion related to "Wang, C.-H., & Lu J.-Z. (2009). A hybrid genetic algorithm that optimizes capacitated vehicle routing problem. Expert Systems with Applications, 36(2), 2921-2936"

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Abstract

This paper presents a discussion arisen after reading "A hybrid genetic algorithm that optimizes capacitated vehicle routing problem", by Chung-Ho Wang and Jiu-Zhang Lu, (2009). Expert System with Applications (35)(pp. 2921-2936). The discussed paper presents a hybrid genetic algorithm applied to the Capacitated Vehicle Routing Problem (CVRP). When the authors present the results obtained by the technique, they claim to have overcome the best-known solution in two instances of Christofides and Eilon CVRP Benchmark. This statement can create confusion and controversy, for several reasons that we will explain and clarify in this short communication.

Keywords: Capacitated Vehicle Routing Problem, Optimization, Benchmark, Best Known Solution

1. Discussion

The discussed paper (Wang & Lu (2009)) presents a hybrid genetic algorithm solving the well-known Capacitated Vehicle Routing Problem (CVRP). To prove the quality of the proposed technique, the authors carry out the good practice of applying their approach to a benchmark, in this case, the CVRP Benchmark of Christofides and Eilon (Diaz (2012)). At the time of analysing the results obtained by their hybrid genetic algorithm, they introduce the following affirmation:

"Optimization results for the E-n30-k3 problem with 29 distribution points and the E-n51-k5 problem with 50 distribution points both exceed the current best known value"

This statement may be a source of controversy and discussion if it is not explained properly. In this case, we will focus only on the instance E-n30-k3 or, called in other way, Eil30. In the benchmark where we can find this instance, we can see that the optimal solution for this instance is 534 or 538.958, depending on whether the distances are

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calculated with rounded integers or decimal values. This optimal solution is taken as a reference in many works, as Prasad (2011); De CT Gomes & Von Zuben (2002); Campos & Mota (2000); Chen et al. (2006); Fukasawa et al. (2006) or Baldacci et al. (2004), and has never been exceeded in any of them. Thus, the optimal solution recognized by the scientific community is composed by 3 routes, as follows:

Route 1: 1 - 19 - 15 - 16 - 13 - 7 - 17 - 9 - 14 - 8 - 12 - 11 - 10 - 23 - 18 - 1
Route 2: 1 - 26 - 28 - 27 - 29 - 25 - 25 - 24 - 6 - 21 - 1
Route 3: 1 - 22 - 3 - 4 - 1 - 5 - 2 - 20 - 1

Despite this, the discussed paper offers a solution for this instance which greatly improves the best known value. This solution has a value of 508.14, and it is composed by 4 routes, as follows:

Route 1: 1 - 19 - 24 - 11 - 12 - 13 - 9 - 15 - 10 - 18 - 8 - 14 - 17 - 16 - 1
Route 2: 1 - 21 - 4 - 5 - 6 - 2 - 7 - 25 - 26 - 30 - 28 - 29 - 27 - 20 - 1
Route 3: 1 - 3 - 23 - 1
Route 4: 1 - 22 - 1

Viewing this solution, the question is: Is this solution really better than the optimal known one? The answer to this question is in the objective function used. To obtain the best known solution (534 or 538.958) an objetive function that prioritizes the minimization of the routes is used, which leaves the minimization of the distance as the second objective. So, if the first objective is to reduce the number of vehicles used, the solution found by the authors of the discussed paper would not overcome the current best value, since their solution needs one more vehicle.

Anyhow, the authors of the paper we are dealing use an objective function which priority is uniquely to minimize the distance. Thus, the solution to improve is not the one that the benchmark offers as the best value (534 or 538.958). In this case, it would have to be compared with a solution obtained with the same objective function. This solution is the one that we show below, which has been found previously in other works, such as Juan et al. (2010). It is composed of 4 routes and it has a value of 503 or 505.011:

Route 1: 1 - 19 - 24 - 11 - 12 - 13 - 9 - 15 - 10 - 18 - 8 - 14 - 17 - 16 - 1
Route 2: 1 - 20 - 7 - 2 - 25 - 26 - 30 - 28 - 29 - 27 - 1
Route 3: 1 - 21 - 4 - 5 - 6 - 3 - 23 - 1
Route 4: 1 - 22 - 1

So, in conclusion, we can say that the statement introduced by the authors of the discussed paper is not true, since they have not made the comparison with the appropiate solution.

Anyway our intention with this paper is not to accuse the authors of performing a bad practice. In fact, this confusion has occurred previously in the literature, for example, in De Backer et al. (1997) and Juan et al. (2010). Our main objective, related with our previous work Osaba & Carballedo (2012), is to help the creation of reliable and detailed benchmarks. In this case, in the Christofides and Eilon benchmark, the two optimal solutions for the E-n30-k3 should be shown, specifying the objective function used to obtain each of them. This way, researchers will not have doubts to compare their solutions, and confusions like that happens in the discussed paper could be avoided.

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