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Knowledge-guided search applied to the transportation of disabled people

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1 Motivations

This research work aims to improve the sanitary transportation in the Rhône-Alpes region in France. The transportation of disabled people from their homes to medical institutes corresponds to a classic operational research problem : the dial-a-ride problem (DARP). In the previous work on the subject, the framework developed in [3] has allowed to solve real-life problems up to 600 users. The goal of this work is to reduce the computation times and increase the size of the problems by taking advantage of the specificities of the problem.

Recent works done in [1], proposed a novel approach to solve routing problems. Usually, the research is about designing strong heuristics tuned well enough to give satisfactory results across a large variety of instances. But in their work, most of the efforts were spent on understanding the structural characteristics of the problem prior to building the heuristic. By knowing the structural differences between good and bad solutions, it is possible make efficient heuristics which integrate this knowledge in their design. This knowledge-guided method allows to solve very large instances of vehicle routing problem (VRP), up to 30000 users within reasonable computation times.

The goal of this study is to improve the performance attained in [3] on real-life problems by extending the work done in [1] from the VRP to the DARP.

2 Method

The method used to set a knowledge-guided search can be decomposed in three steps : data generation, data analysis, integration of specific operators into the optimisation framework.

During the data generation phase, we generate the database from which the structural characteristics of a solution will be learned. First, a large number of instances is generated. As the number of real-life instances is limited, it is necessary to generate artificial, but credible, instances. Then, for each instance, 2 types of solutions are generated and saved : one near-optimal (good) solution and one far-optimal (bad) solution. The goal is to learn the differences between those types of solutions. In order to express the structure of a solution, several

metrics are generated to describe it and its corresponding instance. Thus, one sample in the database corresponds to the solution metrics, the instance metrics and the quality of the solution (good/bad).

During the data analysis phase, classification algorithms are trained to predict the quality of a solution based on its characteristics. First, the classifiers are trained using all the metrics, second, the classifiers are trained using only one solution metric at a time. In both cases, if more than half of the predictions are correct, then it proves that it is possible to accurately know the quality of a solution just by measuring one or multiple metrics. In other words, the characteristics expressed by the metrics allow to differentiate between good and bad solutions.

Finally, the heuristic is designed based on this analysis. New knowledge-guided operators will target the weaknesses of the solutions based on the metrics values.

We take the following example to illustrate the method. During the data analysis phase, the metric "average load per route" allows to correctly predict the quality (good or bad) of 75% of the solution. Further analysis on this particular metric reveals that good solution tends to have a greater average load per route. Then, it is possible to create an operator targeting routes with a low average load and prioritise the insertion of users inside those lightly loaded routes.

3 Current work and perspectives

Before working on real-life application, we realised a proof on concept on artificial instances. We are applying the methodology to instances based on instances from [2]. Promising results are obtained as the classification algorithms are able to make up to 75% of correct predictions on instances with 20 to 50 users and with gaps from 2 to 4% for the bad solutions. If more in depth studies confirm these initial results, the methodology will be adapted to the real-life transportation of disabled people using data coming from NOMAd project ³.

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