Exploration on metaheuristics for solving VRPs

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1 Introduction

Vehicle routing problems is an extension and generalization to the TSP problem. In TSP, given an agent starting from an arbitrary node, we want to find a way it traverses all the nodes and return to the node with the minimal cost. Whereas in VRP (specifically, capacitated VRP), a depot is defined, the agent is assigned an amount of loads and all nodes except the depot is assigned an amount of demands. The agent needs to visit all the nodes to meet their demands, and when its loads is run out, it need to go back to the depot for picking up additional loads. Specifically, we consider the simplest variation of VRP, the CVRP, which only considers capacity constraint. Many real-life applications can be formulized as VRP, such as goods logistics, parcel/food delivery. The problems add more constraint to the TPSs, and are known to be NP-Hard, that is, it is at least as hard as NP where no polynomial-time algorithm to find the exact solution is supposed to exist. Traditionally, vehicle routing problems can be solved approximately with heuristics algorithms. Good practices that have been succeed in solving TSP also have been adapted to solve VRPs. In the project we want to explore how metaheuristics, including evolutionary algorithms, can be used to solve VRPs.

2 Related Work

Exact solutions of VRPs can be found by exact method. Comparing with other methods, exact methods provide exact solutions to a problem but also takes a significantly long time. The most successful method is branch-and-bound which used the divide and conquer strategy. Laporte and Nobert gives a complete and detailed analysis of the branch-and-bound algorithms.

Unlike exact methods, Metaheuristics methods perform a relatively limited exploration of the search space. Some of the metaheuristics that are applied to VRPs are Tabu Search (Glover) and Evolutionary Algorithms and Ant colony Optimization (ACO) (Dorigo, Maniezzo, and Colorni).

3 Research Questions

- How are the metaheuristics adapted to solve VRPs
  - a. When solving TSP in the assignment, we used 2-OPT operation to modify solutions for local search, does the strategy still valid in VRP scenario?
  - b. Can we use n-OPT instead of 2-OPT
  - c. Are there other ways to build solution?
- What kind of metaheuristics are used to solve VRPs
  - a. Does some methods be preferred over others?
  - b. What are their pro and cons of different methods, when to use a certain algorithm
- performance of search algorithms
  - a. Time of execution
  - b. Quality of solution, how close to the exact solution, if exist

  - c. speed of convergence, converge rate

- How are these metaheuristics implemented

4 Data Set and Replication plan

The available benchmark CVRP data sets includes Breedamm; Augerat et al.; Christofides and Eilon; Fisher; Christofides, Mingozzi and Toth, etc. Those data can be found on ProblemInstances. Also, euclidean CVPR problem instances can be sample and generate on-the -fly if no reference solution is needed.
We will determine later in the project which data set to be used when a clearer implementation plan is developed.

5 Overview

A brief literature search and survey will be conducted before the implementation. During the survey, we are expected to identify which kind of implementation will be conduct. Depends on the literature search and available reference implementations, the type of study could be:

- implement a state-of-art algorithm(one paper) to solve CVRP
- implement baseline models and compare their performance
- parallelizing an existing work and compare it with the original one

6 Analysis or implementation Procedure

The algorithms and tools that are considered now includes: Tabu search; Ant Colony Optimization, Evolutionary Algorithms; Google ORTools. The project is expected to be implemented in Python or Java. CPU is required for computation. The resource include our desktop and some remote computing service.

References

[DMC96] M. Dorigo, V. Maniezzo, and A. Colorni. “Ant system: optimization by a colony of cooperating agents”. In: *IEEE transactions on systems, man, and cybernetics. Part B, Cybernetics : a publication of the IEEE Systems, Man, and Cybernetics Society* 26 1 (1996), pp. 29–41.

[Glo86] Fred W. Glover. “Future paths for integer programming and links to artificial intelligence”. In: *Comput. Oper. Res.* 13 (1986), pp. 533–549.

[LN87] G. Laporte and Y. Nobert. “Exact Algorithms for the Vehicle Routing Problem”. In: 1987.