Solving the Vehicle Routing Problem with Multiple Multi-Capacity Vehicles

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Abstract

The Vehicle Routing Problem (VRP) has existed as long as a distributor has needed to deliver items. As such, the VRP has been solved with many different methods, including agent architecture and ant colony modeling. However, these methods have generally been set up for an established organization that has a specific number of vehicles with only a few unique capacities. This project aims to create a program that will solve the VRP, but in a case where all the vehicles could have different capacities. This is the situation faced by some volunteer groups that do not have established vehicle fleets and rely on people volunteering vehicles when something needs to be distributed.

Keywords: Vehicle Routing Problem, heuristics, A* search

1 Introduction

The goal of this project is to create a program to quickly find the most efficient routing of a given number of vehicles with differing capacities to a variety of delivery points with a variety of demands of product. This is a

pure-applied research project. It is being created to assist a volunteer group in their distribution of goods.

The project will involve at least three heuristics. Research will look into the possible heuristics that can be used or the possibility of creating new heuristics. There will be two components to this project. The first will be a route finder that finds road routes between two given points. The second portion will use the route finder to create routes that efficiently distribute the product to all specified delivery points. While "efficiency" has not been defined, it will probably be something similar to product delivered over distance traveled, with the aim of making this number as large as possible.

2 Background

A great deal of research has been done into the VRP and its variants, such as the VRP with Time Windows (VRPTW) and Multi-Depot VRP (MDVRP). Projects have looked into using agent architecture and ant colony optimization to solve the problems. These projects have yielded such ideas as Clarke-Wright Algorithm to place delivery points into routes. Mennell, Shmygelska, and Thangiah did a project to evaluate using agents to solve the VRP. The program used agents to represent the vehicles and "auctioneers" that informed the vehicles of the current situation with regards to customers and deliveries. While the resulting program did not find the optimal solutions for any the sample problems, it was extremely adaptable for the MDVRP and VRP with multi-capacity vehicles.

3 Development

The project will proceed in two stages. First, the route finder will be created. Upon its successful creation, the route creator will be created. Currently, the route finder is approximately 80% done. It is successful as a breadth-first search, but needs the addition of a heuristic.

3.1 Census Data Processing

The road data comes from the US Census Bureau. It was produced in 2006 using the Census Bureau TigerLine system. There are five types of data. RT1, the largest, contains the majority of the information. RT2, RT4, RT5,

and RT6 contain additional information that could not be easily included in RT1. The program reads in all of the records, and uses the common TigerLine ID to link each entry in the different record types. The following table shows the different pieces of data from each record type for a particular road segment. The particular segment is the section of Braddock Road immediately outide TJ.

Record Type Number	Data
RT1	"11106 76033712 A Braddock Rd
RT1 (cont.)	A31 6555 6567 6560 656611112231222312
RT1 (cont.)	51510590599454394543
RT1 (cont.)	45784019124525004521003007 4003
RT2 (cont.)	-77166726+38817271 -77168032+38816700"
RT2	"21106 76033712 1 -77167098+38817200 -77167268+38817182
RT2 (cont.)	-77167327+38817171 -77167439+38817137 -77167616+38817063
RT2 (cont.)	-77167707+38817007 -77167817+38816919 -77167921+38816825
RT2 (cont.)	+000000000+00000000+000000000+00000000"
RT4	"41106 76033712 1 269 "
RT5	"5110651059 269 State Route 620 "
RT6	None

Record Type: 1
Version Number: 1106
TLID: 76033712
Source Code: A
Name: Braddock Rd
Full Name: Braddock Rd
Street Direction: 246.384432363328, Southwest
Length: 0.0843058817053028 miles
CCFC: A31
City: Fairfax County
Start Address, Left: 6555; End Address, Left: 6567
Start Address, Right: 6560; End Address, Left: 6566
Start Impute, Left: 1; End Impute, Left: 1
Start Impute, Right: 1; End Impute, Right: 1
Zip Code, Left: 22312; Zip Code, Right: 22312
Starting Coordinates: +38.817271, -77.166726
Ending Coordinates: +38.816700, -77.168032
Additional Coordinates: [["+38.817200", "-77.167098"], ["+38.817182", "-77.167268"], ["+38.817171", "-77.167327"], ["+38.817137", "-77.167439"], ["+38.817063", "-77.167616"], ["+38.817007", "-77.167707"], ["+38.816919", "-77.167817"], ["+38.816825", "-77.167921"]]]
Additional Names: [["", "State Route 620", "", ""]]
Additional Address: []

3.2 Heuristics

There are at least two heuristics needed for this project. First, the route finder program needs a heuristic to make it reasonably efficient. At this point, an A* search is most likely, although should another search be found that is more efficient, that will be used. Second, the route creator program needs a heuristic. The most likely tool applied here will be a genetic algorithm.

3.2.1 Testing

The only method to test the final project will be to compare it against what a human could do. The program's result in a form such as product delivered over distance traveled would be compared against a human's result in the same form. Also factored in would be the time required for the program and the human to create their results. The means of testing will depend on how "efficiency" is defined. It will likely involve taking amount of product delivered over distance traveled, with the goal being to maximize that number. This would, for a fixed amount of product, indicate less distance had been traveled.

The route finder can be tested at various points by giving it two addresses that have a known best route and evaluating the result of the program. As the program progresses, it can be compared against commercially available mapping programs.

3.3 Results

The goal of this project is to create a program to assist volunteer groups and other organizations that need to deliver items but do not maintain standarized fleets of vehicles. Success will mean that it will be easier for these groups to have events that require the delivery of items. From a programming standpoint, success will mean the successful implementation of multiple heuristics and the integration of multiple programs.

References

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