Vehicle Routing Problem

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1 Introduction

In this document we will explain how we have used the two heuristics - A* and DFBB and two meta-heuristics - Simulated Annealing and Genetic Algorithm for our problem.

2 Problem Formulation

So we have N number of nodes , M types of item , C is the capacity of the car(holds different capacity for each type of item).Now based on demand car has to provide items to different nodes so as to maximise profit and keep the distance covered under a budget. Suppose 3 kinds of item are there , now it can take all 7 possibilities(all except the 000, giving none of the items), if it visits the node.So we have formulated this problem.

3 Heuristic Step-1

Using A* heuristic , we will find out :

- The Hamiltonian cycle with the **shortest possible routes in between** , then take the subset which takes care of the distance budget constraint(the vehicle can travel a d_{max}).Then we will try different ways of taking items to maximise profit , which are possible and which are not, which improve total profit and which do not.
- The Hamiltonian cycle with the **profit/distance ratios maximum between two nodes**.Here the profit in earlier sentence denotes total profit one can make.Then we will again do the distance budget constraint propagation and take a subset out of the cycle.Then we will again try to maximise the profit by taking different possibilities of item inclusion.
- The Hamiltonian cycle with the **maximum profits** in sorted order.Then we will take a subset out of it based on d_{max} constraint and try to maximise profit with different possibilities of item inclusion

4 Heuristic Step-2

Using DFBB we will again find out paths using the above 3 methods.

5 Meta-Heuristic Step-1

Now we have got a total of 6 paths each employed with a different heuristic.Now in this step we will run the meta-heuristic **Simulated Annealing**. We will then run Simulated Annealing parallely on the six paths we have found out.The 3 top paths which have the highest of profits we will take from here.

6 Meta-Heuristic Step-2

Based on the profits of the top 3 paths each will be taking them as parents and do the necessary steps to implement tournament selection(elitism).We will do crossover and mutation and add the best ones to gene pool again and again for a number of iterations.Then we'll choose the path with the maximum profit out of this.

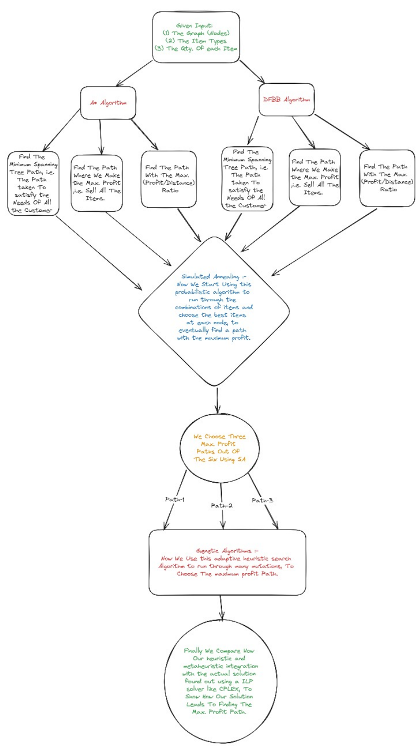

Figure 1: Workflow

7 Evaluation and Validation

So , finally we have the supposed best path.We will check the difference of profit between this path and one given by an ILP solver like CPLEX or a custom code based on PuLP library.

8 Reason to take this Pathway

Here we wanted to explore ways to combine heuristics and meta-heuristics and not just decrease the time of execution for NP-Hard problems like this Vehicle Routing Problem.Here we have both elements of Knapsack problem and Travelling Salesman and , we wanted to explore the relationship between these two.

9 Conclusion

In conclusion, our study showcases the synergistic combination of heuristic and meta-heuristic techniques for solving complex optimization problems like the VRP. By leveraging the complementary strengths of these approaches, we demonstrate significant advancements in route optimization and profit maximization. Our work not only contributes to the field of operational research but also provides practical insights for logistics and transportation industries seeking to optimize their delivery processes.

10 Contributions

Arian Islam(Cs21b1023) , devised the problem, wrote the code for A*, DFBB and PuLP. E.Saileswara Reddy(CS21b1078) wrote the code for Simulated Annealing and Genetic Algorithm implementation.