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Optimization Algorithms

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What is Route Optimization?

Route optimization is the process of determining the most cost-efficient route. It's more complex than simply finding the shortest path between two points. It needs to include all relevant factors, such as the number and location of all the required **stops on the route**, as well as **time windows for deliveries**.

Other Factors

1. Number of turns or intersections along the route
2. Left-hand turns (crossing the line of traffic)
3. Best or nearest driver to dispatch to the route
4. Traffic congestion for the current time of day
5. Best approach (access) to a stop on the route

Source: https://www.verizonconnect.com/ca/glossary/what-is-route-optimization/

Conclusion: We need to consider 2 facts: stops on the route (number of markets) and time windows for deliveries (40 mins time window).

What are the types of Route Optimization Algorithms?

The classification of route optimization algorithms is determined based on the **density of stops they can handle**.

1. High-density routing algorithm

The route optimization algorithm is ideal for managing stops that have more than 150. The software, based on a high-density routing algorithm, is used in different delivery industries like newspapers, postal deliveries, and waste collection.

The delivery stops are closer to each other and require to be visited in one go. The algorithms quickly check different route scenarios based on the real-time traffic, weather, and ETA updates and perform different combinations to deliver a highly optimized delivery route for your drivers

2. Less dense routing algorithm

The less-dense routing algorithm focuses on solving the route optimization problems for 150 or fewer stops. It's ideal for different industries that have delivery positions at distinct points.

Different courier deliveries, food deliveries, or other delivery businesses can use the software based on the less dense routing algorithm.

The software analyzes the different routes for all the spread-out stops and delivers quality route optimization results. The complexity levels increase in this type of algorithm because the stops can be placed far away, increasing the number of scenarios that need to be tested.

3. Special trip algorithm

The routing algorithm considers that the delivery vehicle will make different interval trips during the delivery process.

For example, if the delivery vehicle requires 50 stops at far away locations and is expected to stop after five stops, the algorithm will plan out a different trip that includes visiting a filling station or different grocery stores in the process.

The algorithm calculates the average, duration, and multiple other factors that can deliver optimal routes and solve the vehicle routing problems for your business.

Based on your delivery business, you can choose the ideal route optimization solutions offered by different types of routing algorithms.

Source: https://www.upperinc.com/blog/route-optimization-algorithm/

Conclusion: For our project, we'll use a **less dense routing algorithm** because we won't be delivering wholesale items and thus, won't be traveling 150+ stores.

Base Problem

The Travelling Salesman Problem

The most famous routing problem is the **Traveling Salesperson Problem (TSP):** find the shortest route for a salesperson who needs to visit customers at different locations and return to the

starting point. A TSP can be represented by a graph, in which the nodes correspond to the locations, and the edges (or arcs) denote direct travel between locations.

The problem gets harder when there are more locations. If there are ten locations (not counting the starting point), the number of routes is 362880. For 20 locations, the number jumps to 2432902008176640000. An exhaustive search of all possible routes would be guaranteed to find the shortest, but this is computationally intractable for all but small sets of locations. For larger problems, optimization techniques are needed to intelligently search the solution space and find an optimal (or near-optimal) solution.

A more general version of the TSP is the **vehicle routing problem (VRP)**, in which there are multiple vehicles. In most cases, VRPs have constraints: for example, vehicles might have capacities for the maximum weight or volume of items they can carry, or drivers might be required to visit locations during specified time windows requested by customers. **OR-Tools** can solve many types of VRPs, including the following:

- Traveling Salesperson Problem, the classic routing problem in which there is just one vehicle.
- Vehicle routing problem, a generalization of the TSP with multiple vehicles.
- VRP with capacity constraints, in which vehicles have maximum capacities for the items they can carry.
- VRP with time windows, where the vehicles must visit the locations in specified time intervals.
- VRP with resource constraints, such as space or personnel to load and unload vehicles at the depot (the starting point for the routes).
- VRP with dropped visits, where the vehicles aren't required to visit all locations, but must pay a penalty for each visit that is dropped.

Limitations on solving vehicle routing problems

Vehicle routing problems are inherently **intractable: the length of time it takes to solve them grows exponentially with the size of the problem.** For sufficiently large problems, it could take OR-Tools (or any other routing software) years to find the optimal solution. As a result, OR-Tools sometimes returns solutions that are good, but not optimal. To find a better solution, change the search options for the solver. See Changing the search strategy for an example.

Note: We should add that there are other solvers, such as Concorde, dedicated to solving very large TSPs to optimality, which surpass OR-Tools in that area. However, OR-Tools provides a better platform for solving more general routing problems that contain constraints beyond those of a pure TSP.

Source: https://developers.google.com/optimization/routing

Conclusion: We need to come up with a constraint/limitation on the number of stops on the route, to ease the algorithm development and not make it last years long, and we will use **Vehicle routing problems with time windows** to provide better and more qualified service to our customers**.**

Google OR-Tools

OR-Tools is fast and portable software for combinatorial optimization. It is an open-source software suite for optimization, tuned for tackling the world's toughest problems in vehicle routing, flows, integer and linear programming, and constraint programming. OR-Tools won gold in the international constraint programming competition every year since 2013.

Source: https://developers.google.com/optimization

Conclusion: We can use Google's OR-Tools for the optimization algorithm, and specifically https://developers.google.com/optimization/routing/pickup_delivery.