SmartRoute Optimizer: AI/ML Based Solution

Overview

In today's fast-paced and convenience-driven world, efficient delivery systems are critical to meeting consumer demands. Grocery and essential item deliveries, in particular, require swift and accurate logistics to ensure customer satisfaction and operational efficiency. However, traditional delivery planning processes are often manual, time-consuming, and prone to inefficiencies. These inefficiencies can result in increased delivery times, underutilized resources, and higher operational costs.

To address these challenges, businesses are turning to advanced technological solutions that integrate machine learning, real-time data analysis, and optimization techniques. By leveraging these technologies, delivery systems can optimize resource allocation, enhance route planning, and improve overall operational workflows and reduce operational costs.

At Intech, we frequently encounter firms that can heavily benefit from this automated shipments delivery planning, we recognize the importance of streamlining delivery operations for enhanced customer satisfaction and reduced manual efforts.

Currently, creating and sequencing shipments into delivery trips, while considering constraints such as **time slots**, **delivery vehicle capacities**, and **traffic conditions**, is a complex and resource-intensive task, i.e. generally done manually. Our goal is to develop an innovative solution that automates and optimizes this process.

Problem Statement

This SmartRoute Optimizer delivery planning solution is envisioned as an advanced home delivery solution designed to optimize grocery and essential item deliveries. The system will automatically create trips having multiple shipments and also sequence shipments to optimize the route while addressing key operational goals:

1. **Maximize Vehicle Capacity Utilization**: Efficiently use vehicle space to reduce the number of vehicles required for delivery.
2. **Minimize the Number of Trips**: Optimize the allocation of shipments to reduce overall delivery trips.
3. **Minimize the Overall Distance**: Trips should be created with a view to reduce the overall distance travelled by vehicles.
4. **Be Aware of Trip Completion Time**: Ensure trips are planned within acceptable time limits to meet delivery commitments because users have the option to choose delivery timeslot. (Can use some approximation like MST Distance)
5. **Enable Automated Vehicle Type Allocation**: Assign the most appropriate vehicle type based on number of shipments. **Note:** Priority Vehicles(3W, 4W-EV) should be used first or guaranteed use of them.

6. **Real-Time Traffic Aware Routing(Optional):** You can utilize the real time traffic aware routing using any of the providers or use Minimum Spanning Tree Approach for the approximate distance calculation using geolocations.

Expectation

- Develop an AI/ML based algorithm which would optimize and create trips that satisfies all the **constraints**, **assign appropriate vehicles, utilizes priority vehicles** completely before assigning regular vehicles. Including that the trip should be sequenced in a way to ensure the least travel distance.
- **Output Format:**

  A tabular representation of each trip, consisting of the following parameters:

  Trip_ID, Shipment Details in the Sequence are to be delivered with timeslots, Assigned Vehicle Type and the values for the validation parameters.

TRIP ID	Shipment ID	Latitude	Longitude	TIME SLOT	Shipments	MST_DIST	TRIP_TIME	Vehical_Type	CAPACITY_UTI	TIME_UTI	COV_UTI
T101_1	10	23.2023295	72.66312205	15:00-17:00	4	15	115	3W	0.8	0.96	1
	5	23.199908	72.6660146	15:00-17:00							
	4	23.204751	72.6602295	15:00-17:00							
	8	23.1974865	72.66890715	15:00-17:00							

- **User-Interface(Good to Have):**

  A demo-able user-interface, which would have buttons to call the underlying model, fetch the required shipment data from the Database using Rest-APIs(ideally - as of now you can have endpoints to fetch from csv), display the final trips on the UI in the tabular format. With the integration of a clickable element to show the trip's route on the map.

  - For displaying the trips properly you can use the '*folium'* library of python, to pinpoint the locations and route on the Map. A helping code for the same can be found in the folder shared

Project Steps And Sample Project Explanation

Project Setup

To setup the project necessary data and requirements, you have excel file:

- ***Shipment Data***: The data can be found in ***'SmartRoute Optimizer.xlsx***' under the 'Shipments Data' Sheet. Contains all the details of Shipments with their geolocations and timeslot.

- ***Vehicle Information***: The data can be found in ***'SmartRoute Optimizer.xlsx***' under the 'Vehicle Information' Sheet. Contains the details of all the vehicle types available for deliveries, their shipment capacities and max distance they can cover.

Assumptions

You can make assumptions that are needed for your approach. These are to be listed in the solution documentation. Some of the possible assumptions:

- *Travel_Time_per_km* = 5 mins
- *Delivery_Time_per_Shipment* = 10 mins

Sample Data for Shipments

Below is the example shipment data, consisting of Lat/Long of delivery location and the timeslot we need to make the delivery in.
Assumption: All the shipments are of the same date.

Shipment ID	Latitude	Longitude	Delivery Timeslot
1	23.227771	72.6477279	15:00-17:00
2	23.192612	72.644737	15:00-17:00
3	23.222928	72.653513	15:00-17:00
4	23.209594	72.6544444	17:00-19:00
5	23.2071725	72.65733695	17:00-19:00

These shipments would be packed and dispatched from a warehouse, which we would term as Store, you also have the lat/long information of the store:

Latitute	Longitude
19.075887	72.877911

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The actual values could also be found in ***'SmartRoute Optimizer.xlsx***' under the Store Location Sheet.

Note: Each vehicle/trip is loaded at the store, so every trip starts at the store and ends at the store.

Vehicle Information

Vehicle Type	Number	Shipments_Capacity	Max Trip Radius (in km)
3W	50	5	15
4W-EV	25	8	20
4W	Any	25	Any

Note: The 3W and 4W-EV are priority vehicles i.e., your solution should make sure to use those vehicles before the utilization of other vehicle types such as normal 4W.

Trip Validation Constraints

- **CAPACITY_UTILIZATION**: Any vehicle should not be overutilized, and any trip is only valid if it is occupied by more than 50% of the vehicle shipment capacity
- **TIMESLOT_UTILIZATION**: Each trip should complete within the timeframe(timeslot)
- **COVERAGE_UTILIZATION**: MST Distance of the trip should be within the range of the assigned vehicle type

Multi-Slot Trips

- We can also have multislot trips(i.e., some orders from 15:00-17:00 slot and some from 17:00-19:00 slot), keeping the other constraints in check and availability of vehicles in consideration.
- The deliveries of shipments should be done in a way that shipments of specific slots are delivered in them only, so no shipment before its timeslot or no shipment after the timeslot.
- This is to further enhance the vehicle utilization and decrease the total distance covered by vehicles.

Output

The output should be the trips, with the sequence of shipments to be delivered along with the assigned vehicle information for each trip, where:

TRIP ID	Shipment ID	Latitude	Longitude	TIME SLOT	Shipments	MST_DIST	TRIP_TIME	Vehical_Type	CAPACITY_UTI	TIME_UTI	COV_UTI
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- **MST_DIST**: approximate distance of the trip (from store, to all the delivery points, to back to store)
- **TRIP_TIME**: approximate time for the completion of trip
- **Vehicle_Type**: Assigned vehicle type to the trip
- **CAPACITY_UTI**: the shipment capacity utilization of the vehicle type assigned to the trip
- **TIME_UTI**: the time utilization of the trip to validate if it finishes within time
- **COV_UTI**: the distance utilization of the vehicle type (to check if the trip distance if within the limits of the vehicle type assigned)

Optional

- For displaying the trips properly you can use the ***'folium'*** library of python, to pinpoint the locations and route on the Map. The helping code for the same is provided separately.
- Devise metrics to judge the quality of created trips.

Must Have

- ➔ Design AI/ML based intelligent algorithm which can fulfil above requirements with working demo.
- ➔ Present solution in PPT
- ➔ **Necessary supporting Documentation:** User manuals or technical specifications that may help judges understand project submission.
- ➔ **Demo video:** Good to have, if a short video (2-5 minutes) that showcases the project and its features. This should demonstrate how the project works and how it solves the problem.

Nice to have

- ➔ Covers the integration part with other IT systems
- ➔ Use some Route-API for traffic aware routing and distance approximations

Evaluation Criteria

- ➔ Quality and effectiveness of solution
- ➔ Potential for real-world impact

- ➔ Presentable demo