Inter IIT Tech Meet 11.0
IIT Kanpur

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High Prep

ROUTE PLANNING FOR OPTIMIZED ON TIME DELIVERY

Last mile operations refer to the final leg of the delivery process, where goods or packages are transported from a distribution center or other intermediate location to the final destination , i.e. the customer and end buyer. With the boom in the ecommerce space, everyone from the end buyer, the manufacturer and the seller want it to be as fast as possible. The main objective we are trying to achieve is Efficient On Time Delivery. Thus, optimization and improvisation of the processes involved in last mile operations become a central problem. Building a faster & effective last mile delivery system involves optimization at each step.

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Challenge 1:

Base Challenge:

A last mile hub acts as a temporary storage where items are ingested in and stored , and later a set of these items are delivered from the hub. Since the items are entering and taken out from a hub we need to keep track of the items that comes in and go out from a hub, An efficient hub has the ability to measure the dimensions, weight and condition of the item in least possible time, such tools reduces the time to pick-pack and dispatch the items by huge margins. Hence a tool/device/application that has the ability to measure the dimensions and capture volumetric weights by image, depth or any sensory processing is required . The tool will scan an item placed before it one by one, and estimate the volumetric weight, same items are expected to have similar volumetric weight. Tool will be assisted with a barcode or qr scanner to identify the items (barcoding or qr code scanning is not scope of problem , just to illustrate similar items) , If similar items do not have the weight or dimensions within a range of accepted error, such items should be flagged as erroneous.

Challenge 1.1:

Capture the dead weight of the item along with the volumetric weight.

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Challenge 2:

Description : Last mile delivery operations begin at a last mile hub when a batch of consignments is ready to be dispatched. The batch is scanned for defects in weight and condition and then packed into various bags for a fleet of riders, with each bag assigned to a specific rider. Each tour consists of a fixed duration (roughly 4-5 hours) and includes a number of drop locations (around 20) for the rider to fulfill. During the tour, additional pickup points may be added dynamically, requiring the routing algorithm to efficiently adjust their route to maximize the output of a tour. The picked-up parcels are brought back to the hub. The tour ends when the rider has delivered or picked up the maximum number of items and returned to the original hub.

A route in a tour is the order in which a rider delivers items by navigating a sequence of roads or paths on a map. The rider should be able to view the addresses in this delivery sequence on a map.

During a delivery tour, riders may have empty space in their bags that can be used to pick up additional items on the go. This multi-pickup, multi-drop routing strategy helps to optimize cost, fuel, and time for last mile operations. Therefore, the routing algorithm should be able to identify the best in-transit rider to accommodate these dynamic pickups and drops, ensuring that the tour remains distance-optimized and maximizes productivity. The algorithm should also be able to select the most optimal tour from a group of nearby in-transit riders.

Challenge 2 (Contd.):

The performance or output of a rider is measured as:

On Time Delivery Percentage: Percent of successful deliveries or pickups in a tour before their Estimated Date of Delivery. Estimated Date of delivery (EDD) is a property of consignment to be delivered and will be provided while testing, assuming that the item is dispatched before the EDD of the item.

Fake Attempts Percentage: Percent of delivery attempts faked by rider, i.e, marked as attempted but did not actually attempt to deliver.
Hence capturing where and when the delivery of an item was done, is also key to measure the performance of riders.
Since the main motive of this exercise is to optimize On Time Delivery , these metrics are core to the problems. And while creating the tour plans and routes, maximizing the On Time delivery Percentage, and minimizing the overall distance remain the heart of the problem statement.
The set of algorithms should also be able to identify the number of riders required given maximum available riders.
Since this rider will need to see the order in which he need to attempt the deliveries or pickups , the routing app should be able to navigate the rider on map throughout the tour , hence a navigation system is a must on the application.
For sake of simplicity consider the geographical boundaries of the city of Bangalore.

Challenge 2 (Contd.):

An example to illustrate this process is :

At a hub in Bangalore, there are n orders to be delivered and m riders , a clustering algorithm will cluster these orders into at max m groups based on geo locations of places where order are to be delivered, each cluster will have its own route optimal for delivering.
A last mile executive should be able to deliver and pick up the maximum number of items, travelling least distance possible in a limited period of time. By extension a bag must be created considering optimal route for tour to deliver, has the ability to reroute given pickup points, as well as the maximum optimal count of items a driver should carry in bag given the layout of bag.

Hence this problem can be optimized if we are able to *create rider bags from batch, such that the route created for a bag is optimized for serving multiple pickup and drop points with least distance traveled, also maximizing output from a rider and their bag. Bag creation also involves dimensions of bag, order of the items within the bag, like, an item that is in the initial part of the tour should be on top.*

Route planning is a complex optimization problem that involves distance, rider capacity, geolocation and mapping . It will be a bonus if other complexities like traffic, geospatial context and weather conditions are considered while planning a tour for fleet of riders. It will also be considered a bonus if the weight tool has the ability to detect the condition of the item and flag erroneous items .

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Challenge 2 (Contd.):

Given n items to deliver and a fleet of m riders, (n>m), and some k dynamically added pickup points. Optimize for n items and at most m tours, also considering cases where k>=0 points are added or deleted from the original route .

The Objectives are:

1. A tool that accurately estimates the length, breadth, height and volumetric weight of an item with a small margin of error will receive a higher score. Ease of use and reproducibility of results will also be considered in the scoring. Bonus points will be awarded for challenges mentioned earlier. *(25%)*
2. An effective route planning system to cluster items into different tours that maximizes number of items delivered in each route of tour, **maximizing the on time delivery percentage and minimizing overall distance traveled** on all routes combined with minimum tours/riders involved in fulfillment. While route planning, maximizing output of rider by smart bag creation/clustering to get the best out of riders and routes.

This Route planning system should also have the ability to add pickup points dynamically for multi pickup cases by selecting the correct rider/tour, reroute their routes to cater pickups along with their on going tour, and considering the rider bag capacity as well. *(55%)*

3. A basic platform (web / app) to fit in all these objectives together where points can be added or removed dynamically. The app is expected to support navigation on map by prompting the best route between any two points on the tour for riders. Teams can take liberty to have a separate frontend for the weight measuring tool . *(20%)*

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Final Evaluation

(300 points)

The tool for measuring volumetric weight will be evaluated based on the accuracy of its length, breadth, and height estimates (or its dead weight estimates). The degree of error in the weight of identical items will also be considered. The volumetric weights or dead weights tool will be tested and verified on few items .

The second part of problem will be evaluated on the basis of optimization achieved for the Maximizing on time delivery and minimizing distance traveled. The time complexity and accuracy will also be taken into consideration while scoring.

Final submission is required to have a codebase with detailed description, evaluation will be considered after running on a few test cases, a successful multi pickup dynamic route planning system with focus on optimizing distance traveled, which will be evaluated by running simulations of few test cases.

The route planning will be tested by giving some orders and their addresses, checking the planned routes for various tours and total distance covered by in the tours. For sake of simplicity the higher priority will be given to maximum consignment picked up or delivered, followed by time effectiveness and cost effectiveness , followed by time complexity .

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Mid Term Evaluation *(100 points)*

A mid term evaluation will be conducted on a TBA date, that will have 100 points based on the ideation and a pdf report of at least 500 words describing the approaches and algorithms used in optimizing the route planning , and approach used in the weight detection tool.

Data

A sample data file will be provided containing sample SKUs, picture of items, addresses and EDD to get the context of items, addresses and other relevant information, within a week.