ESI 6314: Deterministic Methods in Operations Research Fall 2023

Course Project

Due: Dec 4

Project Description

In this course project, we propose to solve a Vehicle Routing Problem (VRP). The problem statement is as follows:

A company must deliver products to its customers daily from its distribution center located at coordinates $(0, 0)$ in the plane. The coordinates (x, y) of the customers are given in the attached table, along with the demand of the customer. All the customers correspond to deliveries, i.e., no pickup services are requested. The demand for each customer is deterministic, i.e., known in advance. Some customers' demands can be split, i.e., a part of the demand to be served by one vehicle and the other part to be served by another vehicle. The company could rent 20 trucks that can be used for delivery, each with capacity of 20,000 pounds and a fixed rental cost of $200 per day. Each truck can visit each customer no more than once. Each truck will leave from the distribution center for delivery and then get back to the distribution center with a maximum of one delivery tour per day.

1. Assume the additional cost for the vehicle to travel each Euclidean distance is $3. The company seeks to minimize the total cost to satisfy the demand of all customers. Since this is an NP-hard problem, optimal solutions are not required. The objective is to find a high-quality feasible solution and provide the corresponding objective value. Please justify that your solution is feasible.

2. The VRP with Time Window (VRPTW) is an extension of the VRP in which each customer i is associated with a time interval $[a_i, b_i]$, called a time window. The travel time is assumed to be linear with Euclidean distance, i.e. $t_{ij} = d_{ij}$ (minutes). An additional service time s_i (minutes) for each customer i is also given in the data set. The service of each customer must start within the associated time window, and the vehicle must stop at the customer location for s_i time units. Moreover, in case of early arrival at the location of customer i, the vehicle generally is allowed to wait until time a_i, i.e., until the service may start. With the time window data, find a high-quality feasible solution and the corresponding objective value. Remember to show the reason why your solution is feasible.

3. The company decides to build two more distribution centers located at coordinates $(-50, 50)$ and $(50, -50)$. Considering the company can now dispatch trucks from all three distribution centers, modify your VRPTW formulation accordingly. Find a high-quality feasible solution and the corresponding objective value. Remember to show the reason why your solution is feasible.

The team with the lowest cost is the winner of the project.

Project Delivery

Provide a project report that shows the number of vehicles needed and the route for each vehicle, besides providing the objective value for each above question. You are also required to write a description of your solution approaches. The report should be no more than five pages.