The relationship between TSP and delivery

Joon-Ha Park, joonhapark811@gmail.com
Eastside Christian High School, Class of 2019
USC Viterbi Department of Industrial & Systems Engineering, SHINE 2018

USC Viterbi School of Engineering

SHINE Summer High School Intensive in Next-Generation Engineering

Introduction

In Professor Carlsson's lab, we attempted to solve the Traveling Salesman Problem, an NP-Hard problem with a salesman planning to visit a list of locations exactly once. However, it does not end there as the main problem is to find the optimal route, meaning a tour with least miles travelled. Also, one of the most frequently asked questions is if the use of autonomous drones can facilitate the traditional truck delivery system.

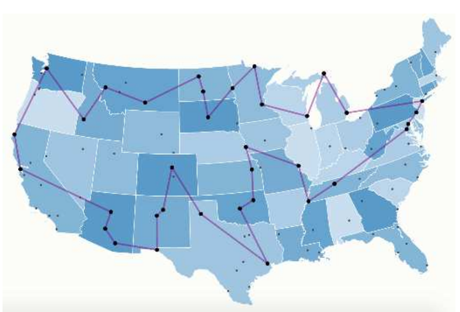

Figure 1: an optimal tour of USA. PC: Gurobi Interactives

Objective & Impact of Professor's Research

The objective of Professor Carlsson's research was to understand the efficiency of the different algorithms to solve TSP problems. The impact of this research can be used in many different fields. Specifically the comparison of the efficiency of drone delivery, man-operated delivery, and the combination of those two: Horsefly delivery. Horsefly delivery is when the truck is moving and acting as a temporary depot as drones are flying out of the truck and delivering packages.

In Professor John Carlsson's research paper, "Coordinated Logistics with a truck and a drone," he focuses on and goes in depth into the Horsefly delivery to see how it will be more efficient than truck delivery and drone delivery.

Figure 2: A depiction of an Amazon Prime Air drone in New York

PC: YouTube

Skills Learned

Matlab®: a widely used coding language based on matrices used by engineers.

- Use **Matlab®** to realize multiple algorithms and to plot the results out and then analyze them.

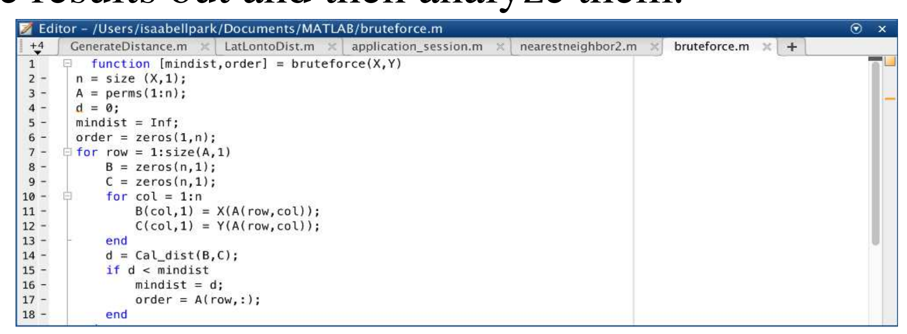

Figure 3: Example of an algorithm in Matlab. PC: Joon-Ha Park

Algorithms:

a) Brute Force: The route is guaranteed to be optimal, because it tries all combinations possible. However, it takes way too long when there are many nodes.
b) Cheapest Insertion: Insert a random node into an already existing tour by minimizing the insertion cost.
c) Nearest Neighbor: Start with a random node and moving on to the closest point to the current node.
d) Near-Optimal: A fast algorithm to approximate the optimal tour.

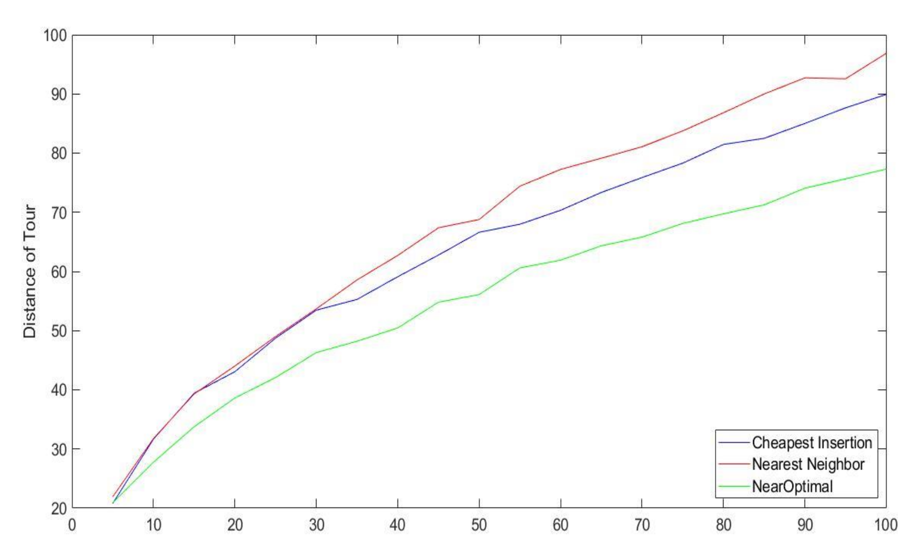

Figure 4: comparison of the algorithms

Graphs

- Complete vs. incomplete, directed vs. undirected, weighted vs. unweighted
- Trees – Connected set of points with no loop
- Minimum Spanning Tree – a tree that connects every node in the graph with the smallest cost
- Eulerian Tour – a tour that goes through all edges once and go back to the start node

TSP transformations

- Incomplete to Complete TSP
- Multiple trucks to single trucks TSP

Projects & Experiments

Application

Problem Definition: We are using data that came from a fashion line. This fashion line had 39 customers, and it was our job to find the most efficient route using only one truck.

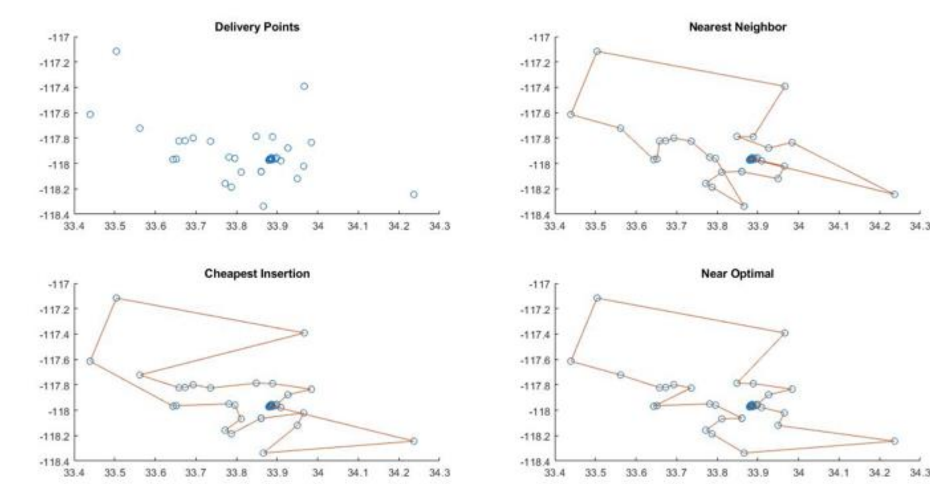

Figure 5: Locations and tours of 3 algorithms.

Data:

- Each node represents the customer delivery point in longitude and latitude
- A majority of the nodes are clustered around the depot while some lie far away from the depot

Results:

- For Nearest Neighbor and cheapest insertion, the route is long and there are some overlaps.
- For Near Optimal, the route is significantly shorter and there aren't any overlaps visible.

Extension

Problem Definition: Use the same points there were from the fashion line and try to construct an efficient route using K trucks. (K>1)

Algorithm:

1. Start using only one truck
2. Use Nearest Neighbor to insert locations into the truck.
3. Add a new truck if the total distance exceeds the travel limit.
4. Use near optimal TSP to improve the route for each truck.

Results & Analysis: Even though K trucks travel a longer distance, the time span decreases if K trucks run simultaneously. This extension better represents the reality where customers demand fast delivery.

Projects & Experiments cont.

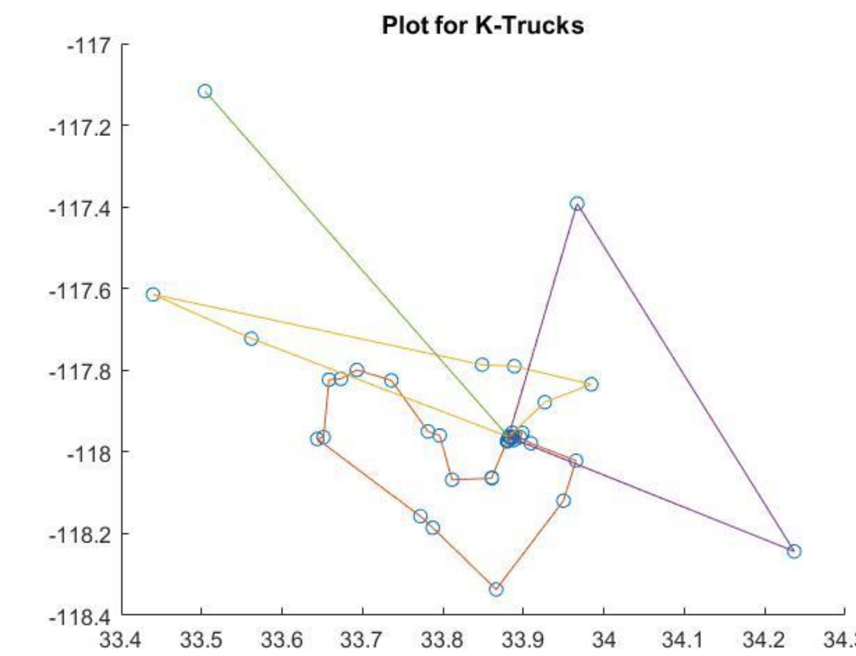

Figure 6: K trucks tour

Next Steps for You OR Advice for Future SHINE Students

My next steps are definitely as a rising senior, applying to USC, which has been my dream school since I was a little kid watching USC football on TV. I am definitely going to apply as the Industrial & Systems Engineering after this experience at USC Shine as an undergraduate and hope to get a job in the transportation area. My advice is to always be attentive as everything I have learned here does not only store as knowledge, but it has also been helping in real life situations. Also, raise your hand and be confident! One of the main things Dr. Katie Mills and the SHINE team focus on is improving communication skills as she gives a lot of opportunities to speak up and talk to others so take advantage of it!

Acknowledgements

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