The Subway Challenge

Kuleen Sasse, Beryl Castello, Michael Dinitz
Department of Computer Science | Department of Applied Mathematics and Statistics
Johns Hopkins University

Abstract

The Subway Challenge is an open record put out by the Guinness World Records Company. The goal of the challenge is to visit all 472 stations on the New York City Subway System in the shortest amount of time. We transformed the New York Subway System into a representation that a computer can solve. We then ran a couple different solvers on our representation: Nearest Neighbor Search and Ant Colony Optimizer. Through trial and error, we found multiple tours that beat the world record.

Introduction

- Subway Challenge: Open record put out by the Guinness World Records Company
- Goal: Visit all 472 stations on the New York City Subway system in the shortest amount of time.
- Similarities to other problems in Computer Science/Optimization
  - Traveling Salesperson Problem (TSP)
    - Famous problem with a variety of applications
    - What is the fastest way to visit a set of cities and return home?
  - Time Dependent Traveling Salesperson Problem (TDTSP)
    - Variation of TSP
    - Asks the same question
    - Adds that the cost to go between cities changes over time
- Differences
  - Cannot visit all other stations from another station immediately, restricted to Subway lines
  - Does not have to be a single cycle that passes through all stations exactly once
  - Additional parameters such as starting station and starting time of day affect traveling times

Methods

- Code was written in C++ and Python
- Transformed subway data from MTA to Time Expanded Graph
  - Edges appear and disappear over time
  - Traveling times on an edge can vary with time
- Added edges between stations that were in 2 miles of each other (running distance)
- Ran two types of solvers on the graph
  - Nearest Neighbor Algorithm
    - Greedy Algorithm
    - Adds nearest station to tour
  - Ant Colony Optimizer
    - Based on ants foraging for food
    - Ants create random tours to food at first
    - Develop faster tours based on previous iterations
    - Generated best results so far

Results

Figure 2: Map of NYC Subway System

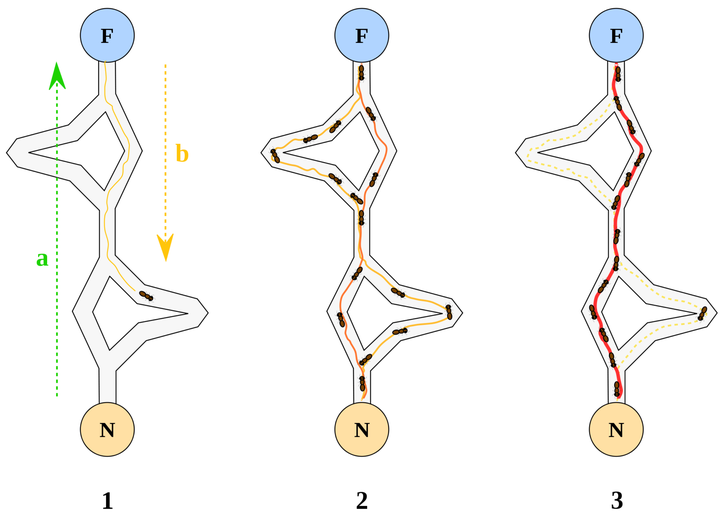

Figure 1: Visualization of Ant Colony Optimization

Figure 3: Segment of Best Tour Found by Ant Colony

Solver Method	Starting Station	Starting Time	Total Time
Current World Record	Far Rockaway-Mott Av	2:00 AM	22H:15M*
Nearest Neighbor	Carnarise-Rockaway Pkwy	9:40 AM	24H:12M
Ant Colony	Pelham Bay Park	2:20 AM	**22H:10M**

Table 1: Best Results of Methods

Next Steps

- Go to NYC and execute the tour!
- Investigate alternative methods of formulating the problem
  - Set TSP (generalization of TSP)
  - Railway Traveling Salesperson Problem (different formulation)
- Use Different Solvers
  - ILP Formulation
  - Genetic Algorithm
  - Lin–Kernighan Heuristic/Concorde (classic TSP solvers)

Acknowledgements and Additional Questions

This work was carried out at the Advanced Research Computing at Hopkins core facility which is supported by the National Science Foundation grant number OAC1920103.

Thank you to Professor Dinitz for supporting this endeavour.

Thank you to Professor Castello for mentoring me throughout the semester.

Thank you to Asher Desai for creating the base code I used.

Further Questions? Reach out to me on Twitter: @KuleenSasse