Traveling Santa Problem

SCM 702 : Group 5

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Objective/Who Cares and Why?

In the night of December 25th, Santa Claus wants to deliver gifts to children across 40 most populous cities in the United States. We want to help him find the optimal path such that:

- Children get their gifts on time
- Santa's reindeers are not exhausted, as they have to travel back to North Pole

In this project, we use the Traveling Salesman Problem (TSP) in Management Science to help Santa figure out a way so that he can travel the least possible distance, and cover all the cities.

Data

The data is a .csv file containing various information on 28,890 US cities.

Columns utilized for the project includes:

- City Name
- Latitude
- Longitude
- Population

Source: https://simplemaps.com/data/us-cities

Methodology pt.1

Step 1: Shortlist the top 40 cities ranked by population in descending order.

Step 2: Construct a two-dimensional Euclidean distance matrix by using latitudes and longitudes using the following formula:

$$\text{Euclidean distance} = \sqrt{(\sum(\text{Latitude of City}_1 - \text{Latitude of City}_2)^2 + \sum(\text{Longitude of City}_1 - \text{Longitude of City}_2)^2)}$$

Step 3: Setup the problem to minimize the sum of the total Euclidean distance after traveling to each one of the 40 cities only once.

Methodology pt.2

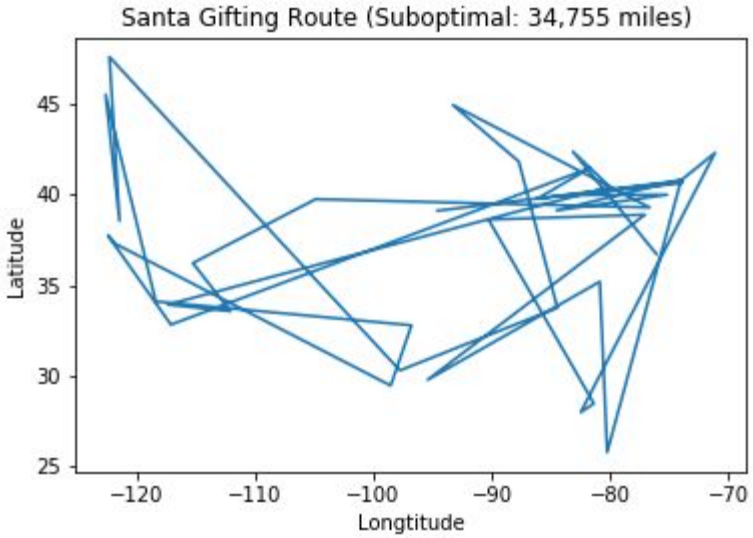
Step 4: Use Evolutionary solver method (as the problem is non-linear in nature) to optimize the total distance. One can make changes in the starting point, runtime, mutation rate, and convergence rate, to obtain multiple results.

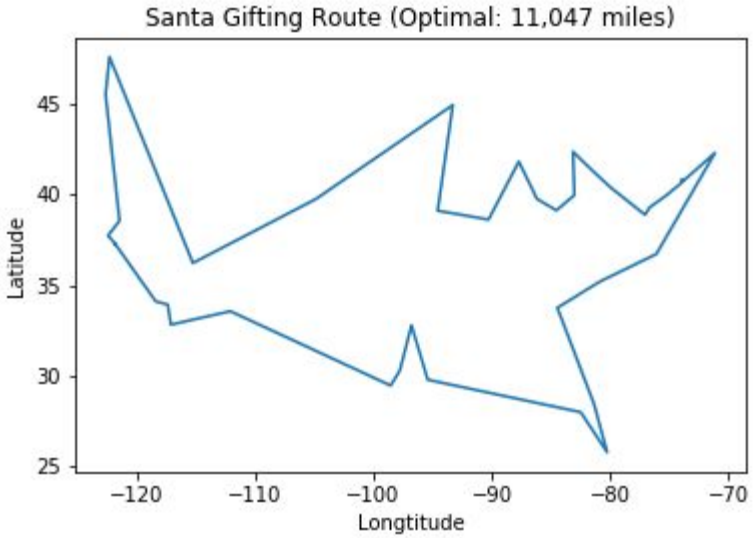
NOTE: Minimizing the distance is the same as maximizing reindeers' flight range to return home

Step 5: Each degree in latitude and longitude is around 69 miles. Therefore we will multiply the final distance in degrees by 69 to obtain the final distance in miles.

Results/Visualizations

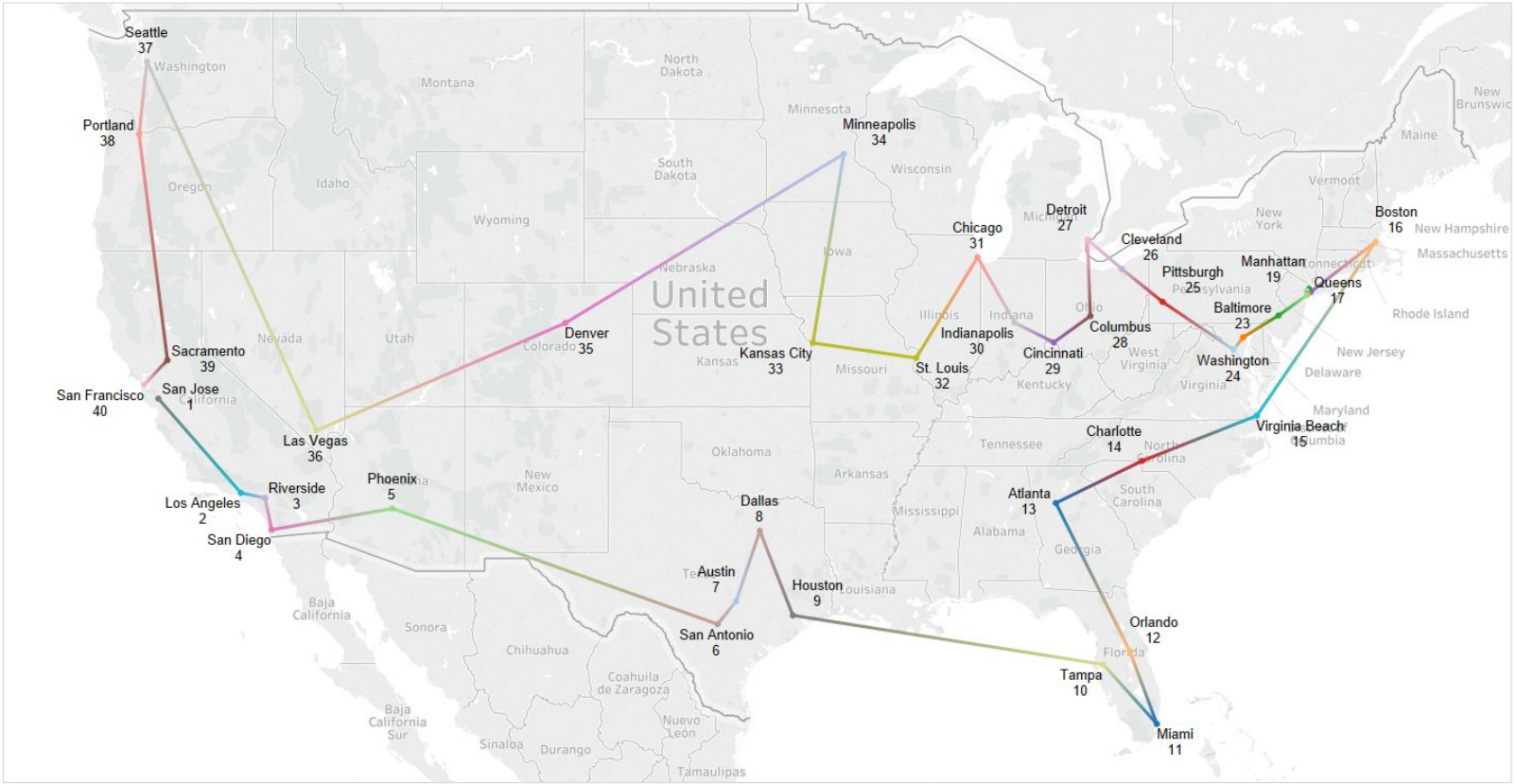
- The optimal result suggests that Santa has to travel a minimum of 11,047 miles
- There can be multiple optimal solutions, due to global and local minimas





Optimal Path - Tableau

Sheet 2



Map based on average of Longitude (Sheet1 (TSP_TAB.V1)) and average of Latitude. Color shows details about Cities as an attribute. The marks are labeled by Cities and sum of Sequence. Details are shown for Cities.

- Atlanta
- Austin
- Baltimore
- Boston
- Bronx
- Brooklyn
- Charlotte
- Chicago
- Cincinnati
- Cleveland
- Columbus
- Dallas
- Denver
- Detroit
- Houston
- Indianapolis
- Kansas City
- Las Vegas
- Los Angeles
- Manhattan
- Miami
- Minneapolis
- New York
- Orlando
- Philadelphia
- Phoenix
- Pittsburgh
- Portland
- Queens
- Riverside
- Sacramento
- San Antonio
- San Diego
- San Francisco
- San Jose
- Seattle
- St. Louis
- Tampa
- Virginia Beach
- Washington

Insights

- The solution suggested that Santa will be making more stops in the east and west coast such as NY and CA, and not so much in the midwest or the south

- The flight path with no intersections is more optimal, because a city's airspace that is covered once must not be covered again

- If Santa wants to visit other destinations in the world, he can scale this model to do so in an optimal way

- The model can be used for other use cases such as logistics management, transportation, and sales operations

THANK YOU!