

# Travel Time Optimization Problem via Ant Colony and Genetic Evolution

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RISHIKA DRONA

A promotional image for Uber and Lyft. The background is a dark, reflective surface, possibly a car, with a large, shiny chrome wheel visible on the left. A person wearing a tan trench coat, blue trousers, red socks, and brown shoes is standing on the right side, holding a black bag. The word "UBER" is written in large, white, sans-serif capital letters on the left. The word "lyft" is written in large, pink, lowercase letters on the right. A vertical pink line separates the two logos.

UBER

lyft



**NYC TAXI DATA**

**XGBOOST**

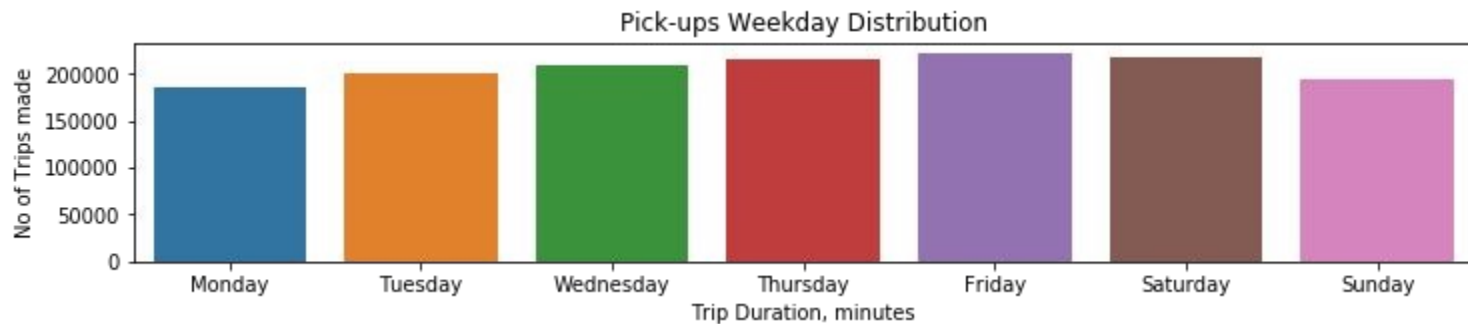
**EVOLUTIONARY  
ALGORITHM**

# NYC Taxi and Limousine Commission Trip Record

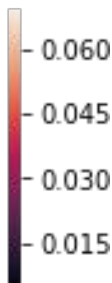
- 1.5 Million Trips
- Year 2021
- 11 Attributes:
  - Id
  - Vendor\_id
  - Pickup\_datetime
  - Dropoff\_datetime
  - Passenger\_count
  - Pickup\_longitude
  - Pickup\_latitude
  - Dropoff\_longitude
  - Dropoff\_latitude
  - Store\_and\_fwd\_flag
  - Trip\_duration



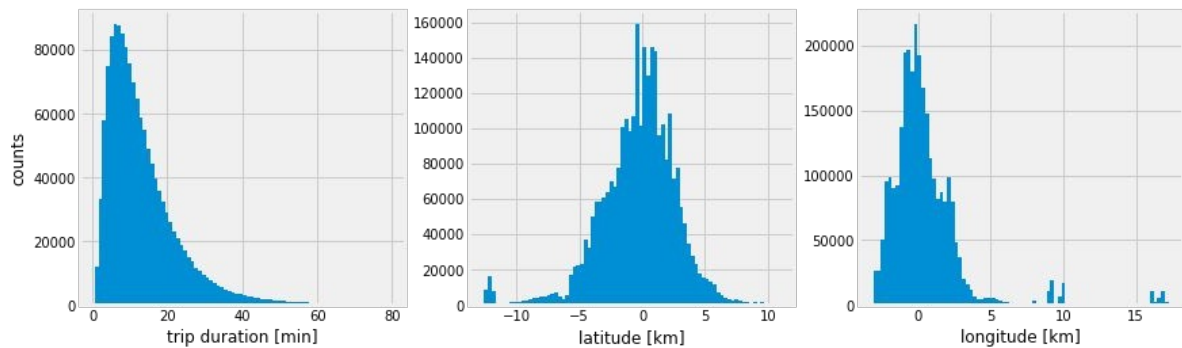
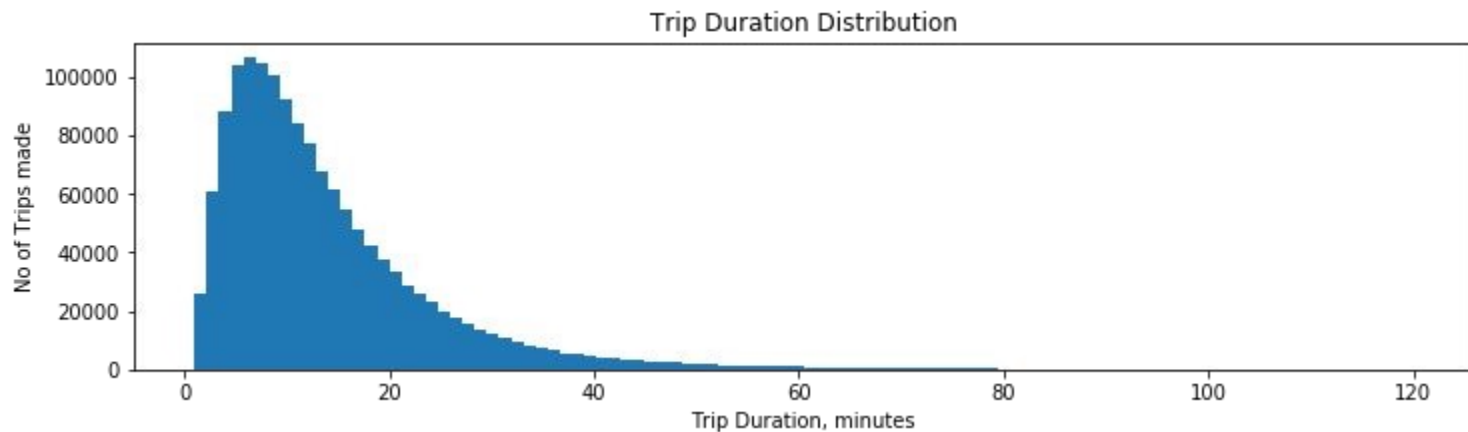
# Pick-Up Times



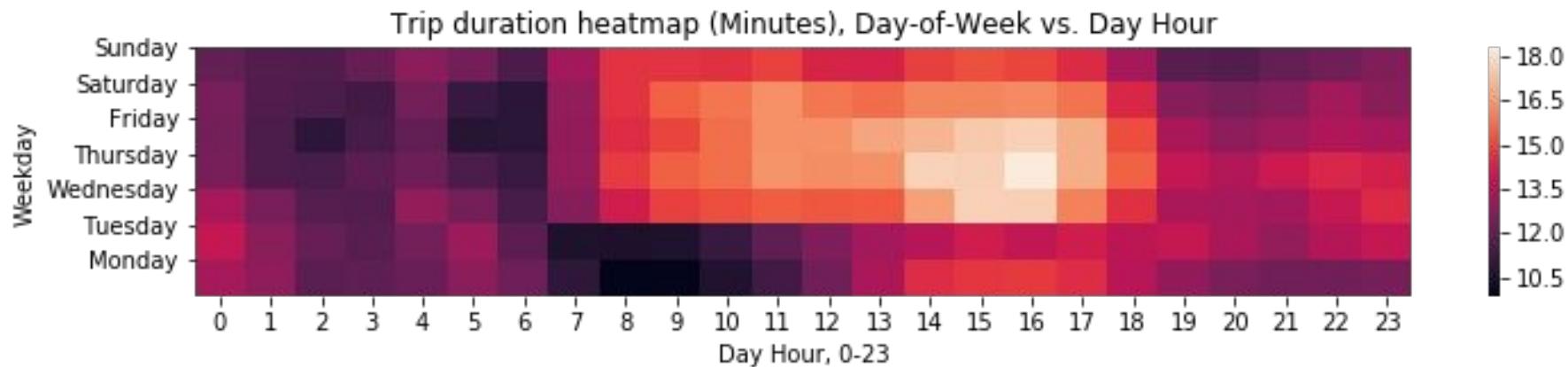
Weekday



# Trip Duration

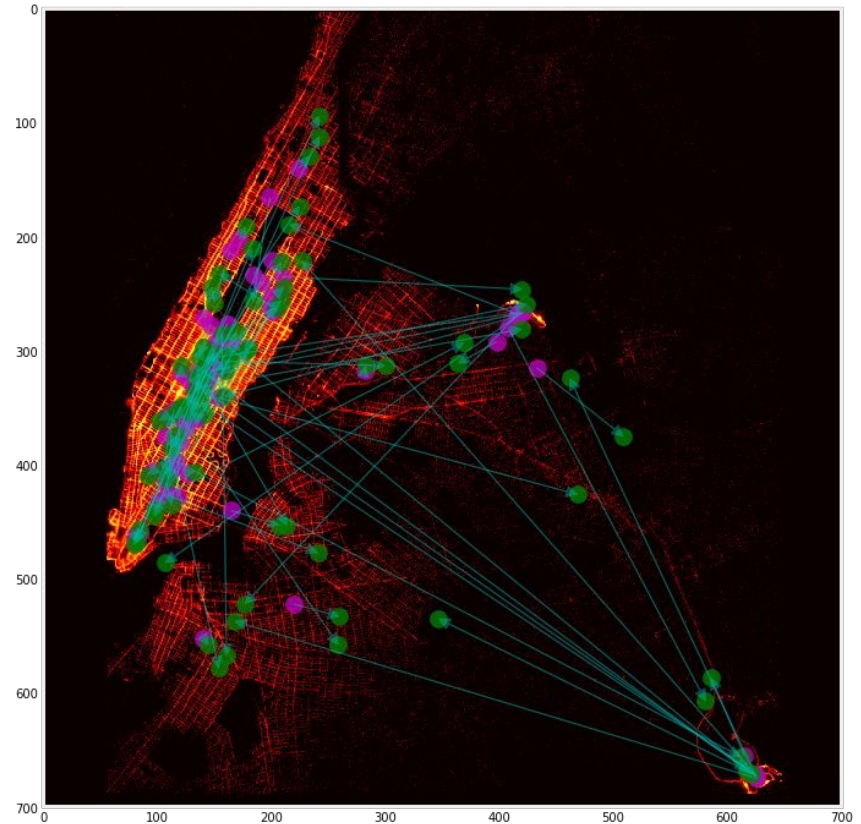
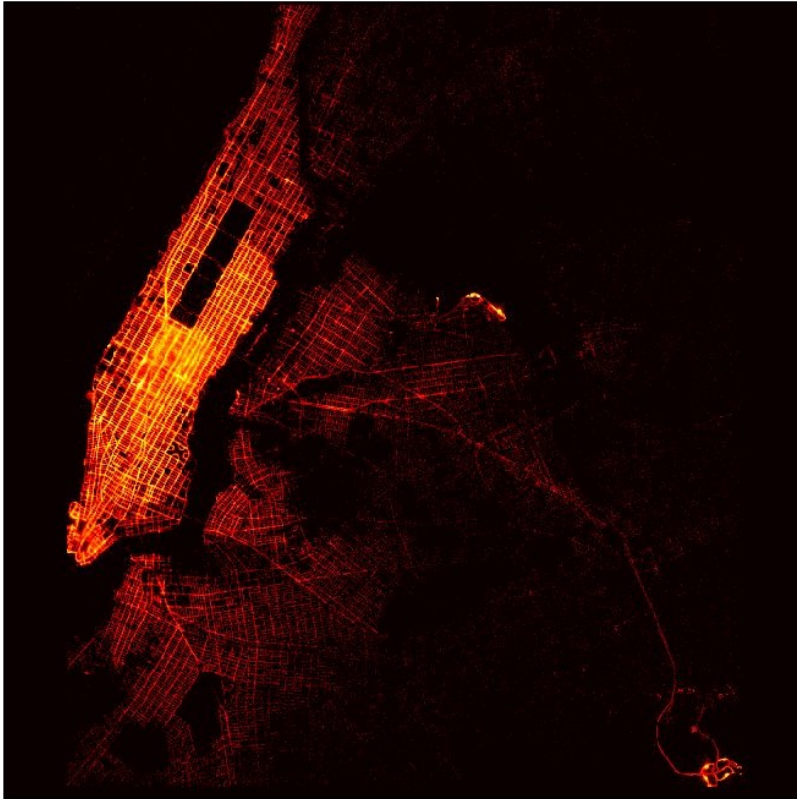


# Trip Duration





# Pickup and Dropoff Locations



# Machine Learning

- Features: passenger\_count, pickup\_longitude, pickup\_latitude, dropoff\_longitude, dropoff\_latitude, store\_and\_fwd\_flag
- Target: trip\_duration
- XGBoost's Hyperparameters:
  - Learning\_rate = 0.05
  - Max\_depth = 14
  - Subsample = 0.9
  - Silent = 1
  - Feval = rmsle

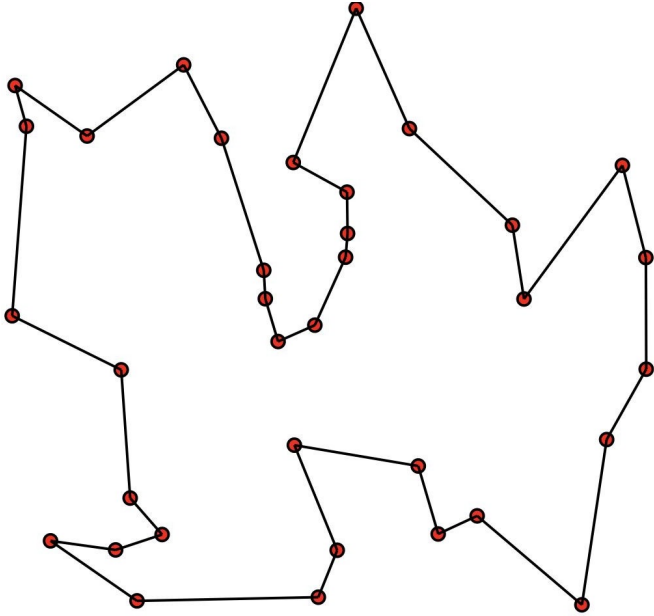


# Proposed Solutions

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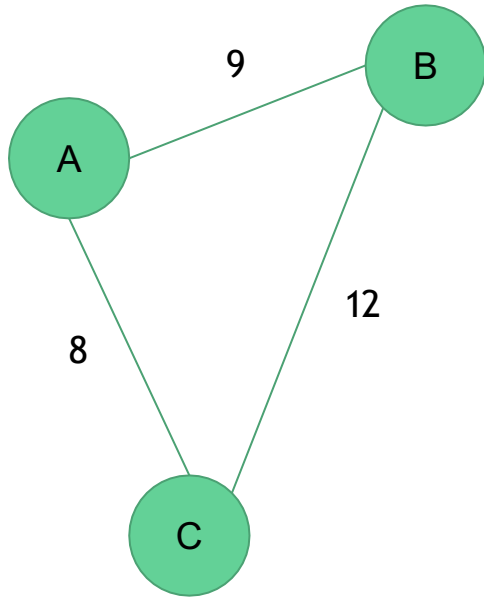
Ant Colony & Genetic Evolution Optimization

# Traveling Salesman Problem (TSP)



$$O(n) = \left[ \frac{1}{2} (n - 1)! \right]$$

# Ant Colony Optimization



$$\tau = \begin{pmatrix} \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \\ \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \\ \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \end{pmatrix}$$

$$\eta = \begin{pmatrix} 0 & \frac{1}{9} & \frac{1}{8} \\ \frac{1}{9} & 0 & \frac{1}{12} \\ \frac{1}{8} & \frac{1}{12} & 0 \end{pmatrix}$$

# Ant Colony Optimization

$$p_{ij} = \frac{[\tau_{ij}]^{\alpha} [\eta_{ij}]^{\beta}}{\sum_{h \in \mathcal{E}} [\tau_{ih}]^{\alpha} [\eta_{ih}]^{\beta}}$$

# Ant Colony Optimization

```
# Update phermones based on total path cost
self.pheromone_delta[i][j] =
    self.colony.Q /
    self.total_cost
```

```
graph.pheromone[i][j] *= self.rho
for ant in ants:
    graph.pheromone[i][j] += ant.pheromone_delta[i][j]
```

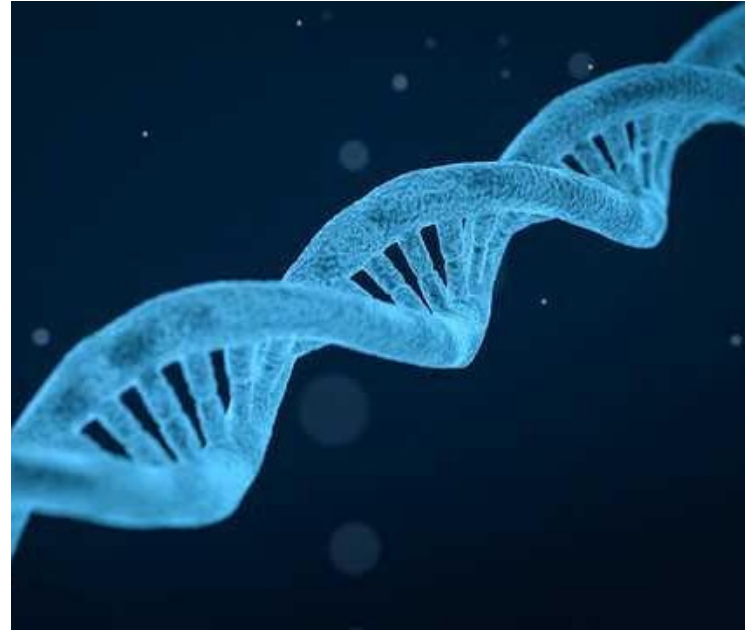
# Ant Colony Optimization

$$p_{ij} = \frac{[\tau_{ij}]^{\alpha} [\eta_{ij}]^{\beta}}{\sum_{h \in \mathcal{E}} [\tau_{ih}]^{\alpha} [\eta_{ih}]^{\beta}}$$



# Genetic Evolution Optimization

1. Create a population of routes
2. Mutate
3. Crossover
4. Determine the fitness (travel time)
5. Select parent for next generation
6. *Repeat from step 2*



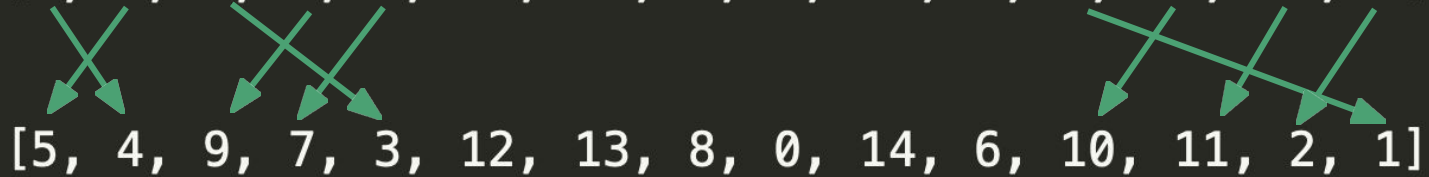
# Mutation

Original Path:

[4, 5, 3, 9, 7, 12, 13, 8, 0, 14, 6, 1, 10, 11, 2]

[4, 5, 3, 9, 7, 12, 13, 8, 0, 14, 6, 1, 10, 11, 2]

[5, 4, 9, 7, 3, 12, 13, 8, 0, 14, 6, 10, 11, 2, 1]



Mutated Path:

[5, 4, 9, 7, 3, 12, 13, 8, 0, 14, 6, 10, 11, 2, 1]

# Crossover

Current Path:

[2, 6, 10, 0, 7, 3, 14, 11, 1, 9, 8, 4, 5, 13, 12]

Mutated Path:

[14, 12, 13, 10, 11, 8, 0, 3, 7, 1, 5, 4, 2, 6, 9]

Offspring Path:

[14, 12, 13, 0, 7, 8, 14, 11, 1, 1, 5, 4, 2, 6, 12]

# Crossover

Offspring path with duplicates removed:

[14, 12, 13, 0, 7, 8, 11, 1, 5, 4, 2, 6]

Missing locations:

[3, 9, 10]

Final offspring path:

[14, 12, 13, 0, 7, 8, 11, 1, 5, 4, 2, 6, 3, 9, 10]

# Evaluate Fitness

```
# Selection
# Select parent based on smaller path cost
candidate_cost = total_cost_from_path(candidate)
curr_cost = total_cost_from_path(curr_element)

if candidate_cost < curr_cost:
    population[i] = copy.copy(candidate)
```

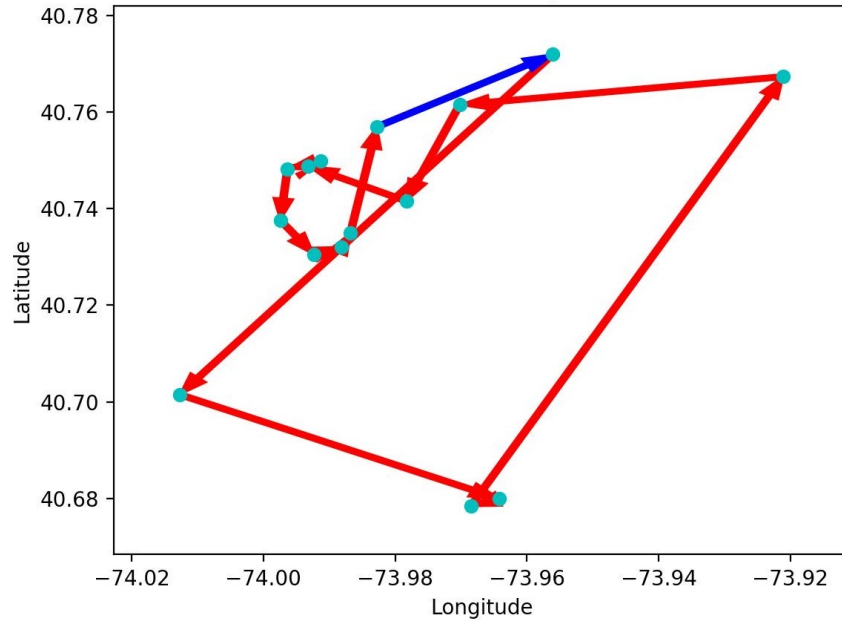
# Experimental Results

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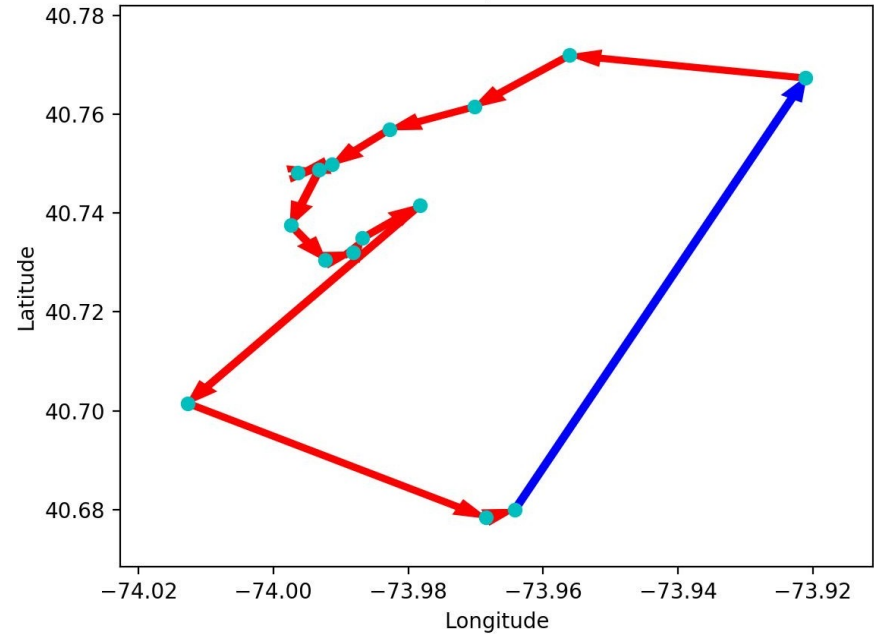
Ant Colony & Genetic Evolution Optimization

# Generated Optimal Paths

Genetic Evolution Path By Travel Time

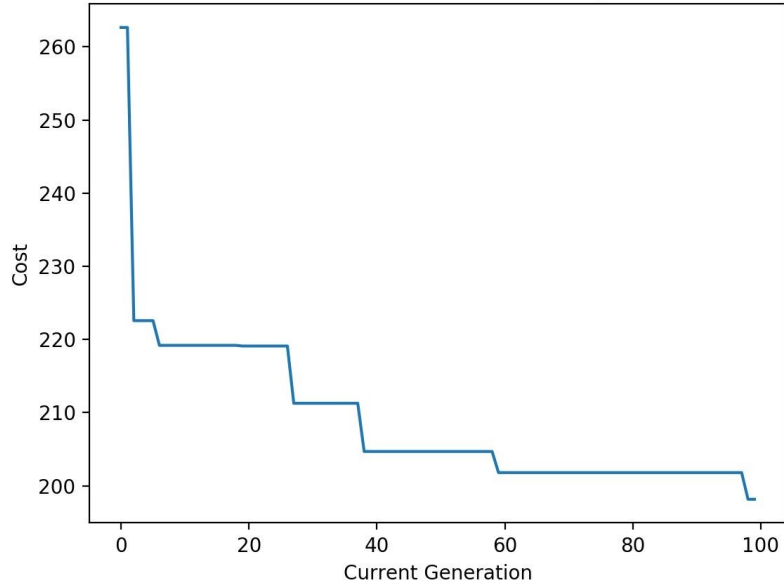


ACO Path By Travel Time

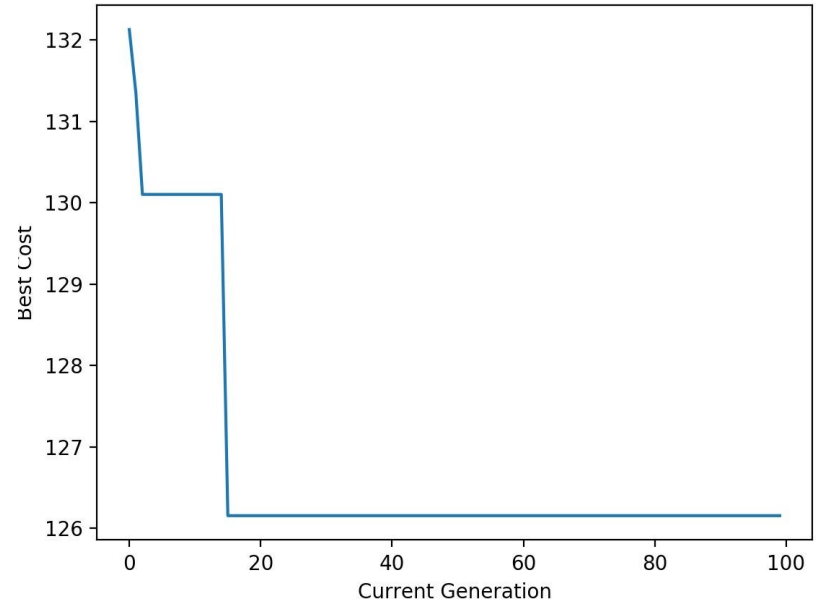


# Optimal Cost Per Generation

Best Cost vs Generation for 100 Population

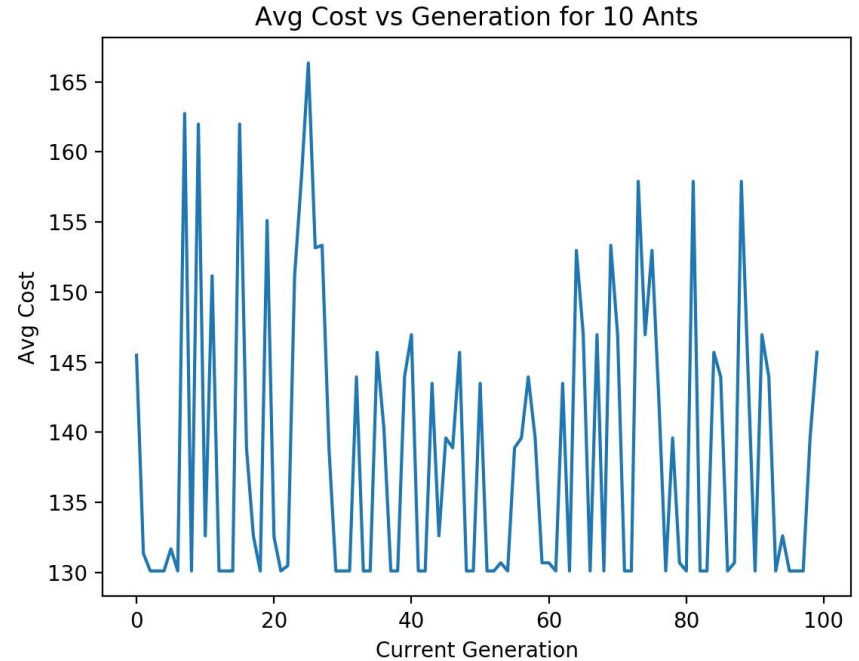
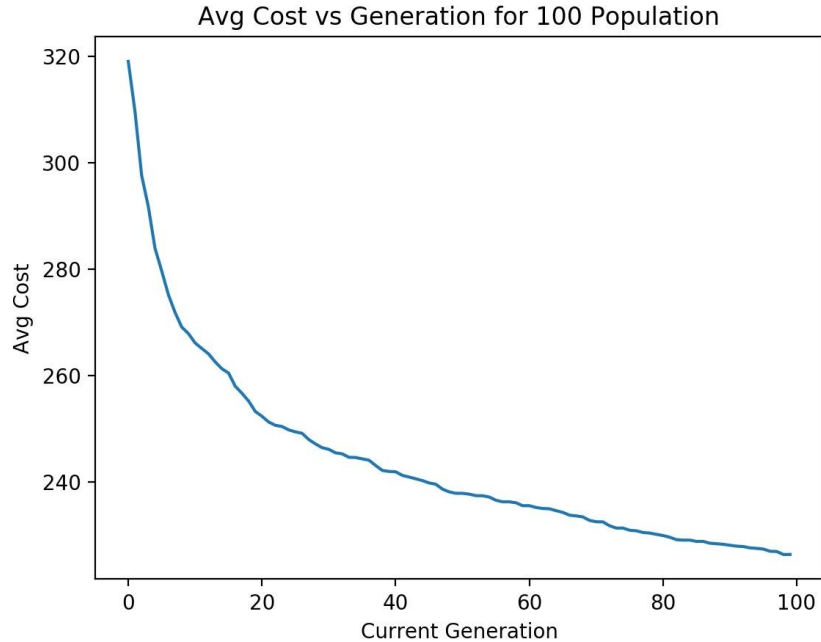


Best Cost vs Generation for 10 Ants



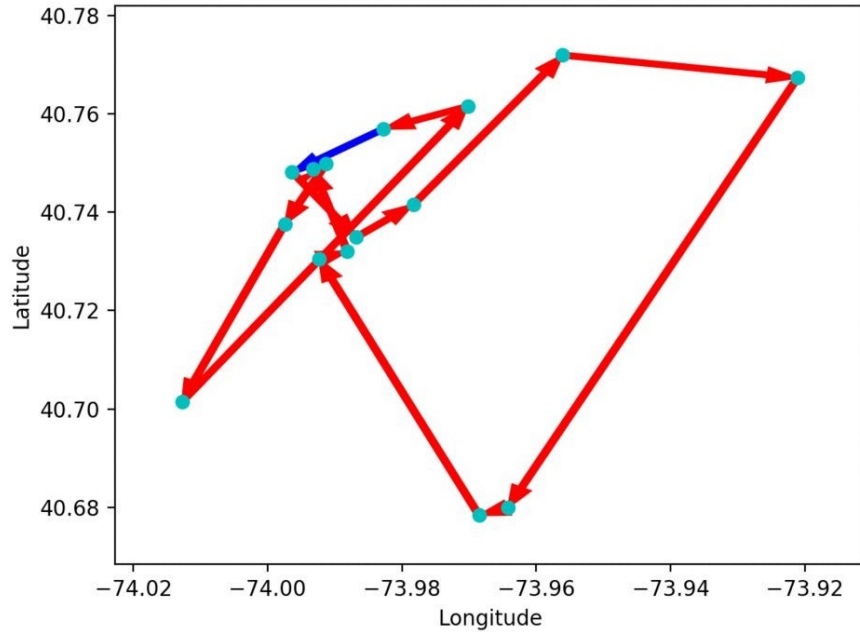


# Average Cost Per Generation



# Generated Paths

Genetic Evolution Path By Travel Time



ACO Path By Travel Time

