Travel Time Optimization Problem via Ant Colony and Genetic Evolution

RISHIKA DRONA


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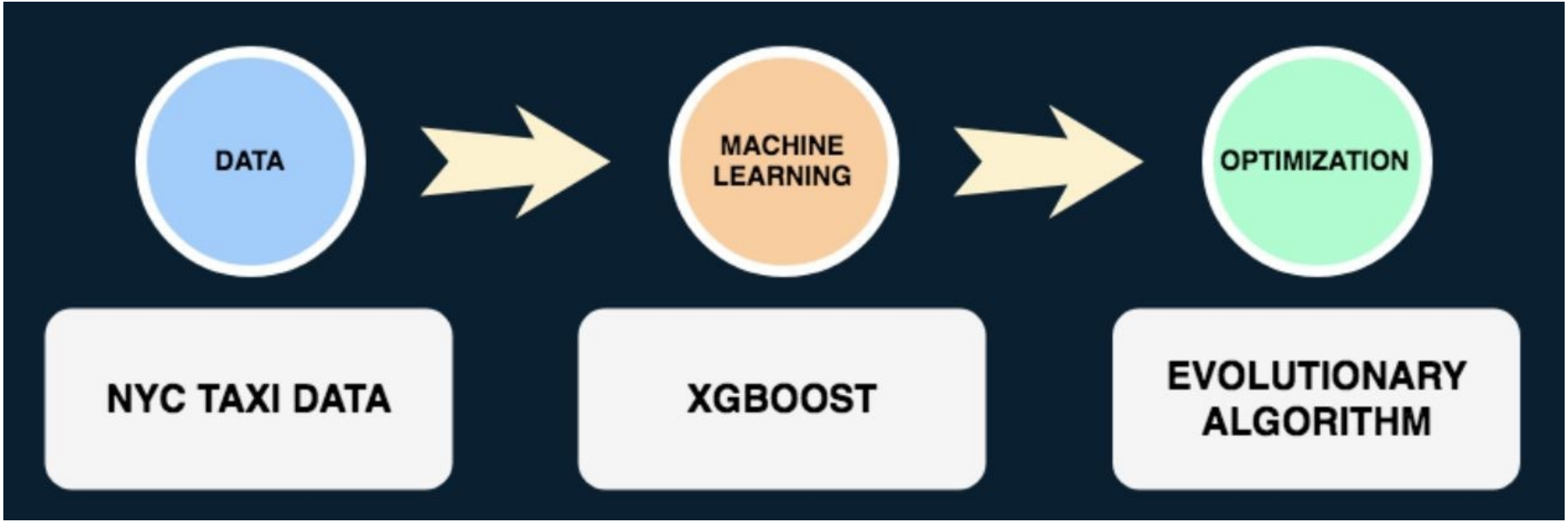
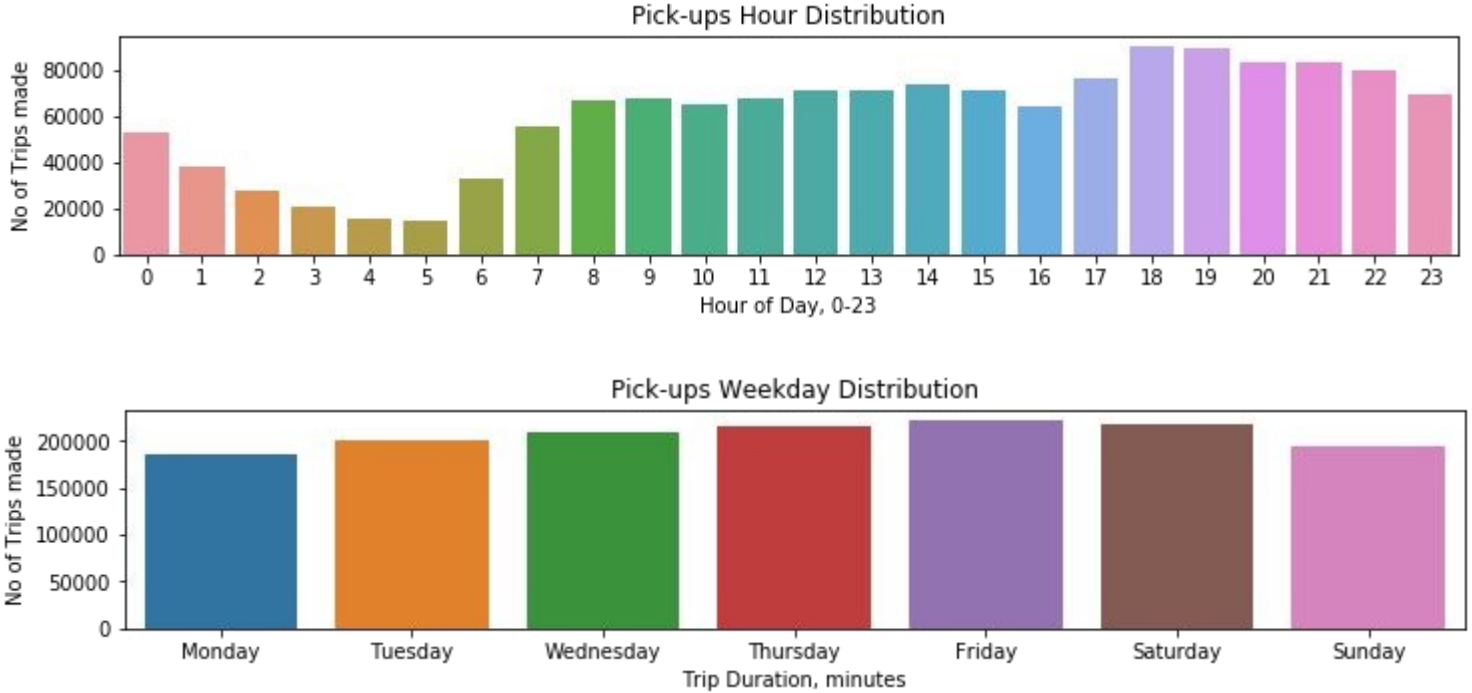

DATA
MACHINE LEARNING
OPTIMIZATION
NYC TAXI DATA
XGBOOST
EVOLUTIONARY ALGORITHM

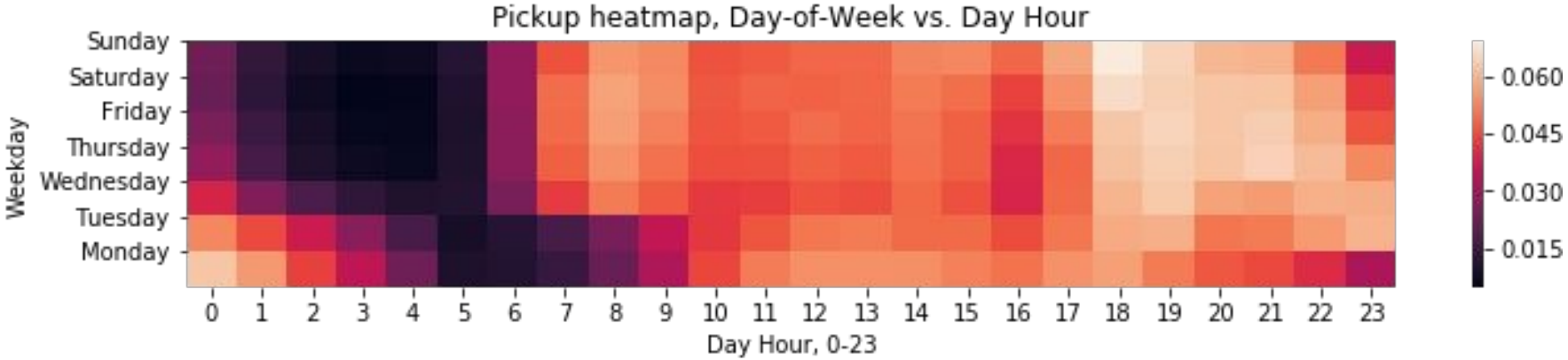
NYC Taxi and Limousine Commission Trip Record

- 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

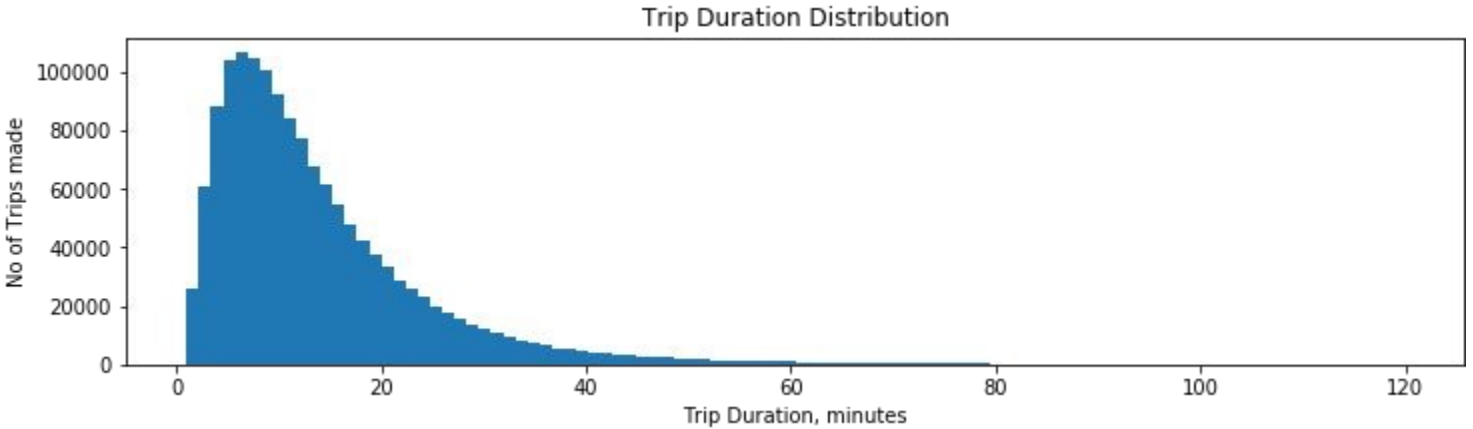
Pick-Up Times

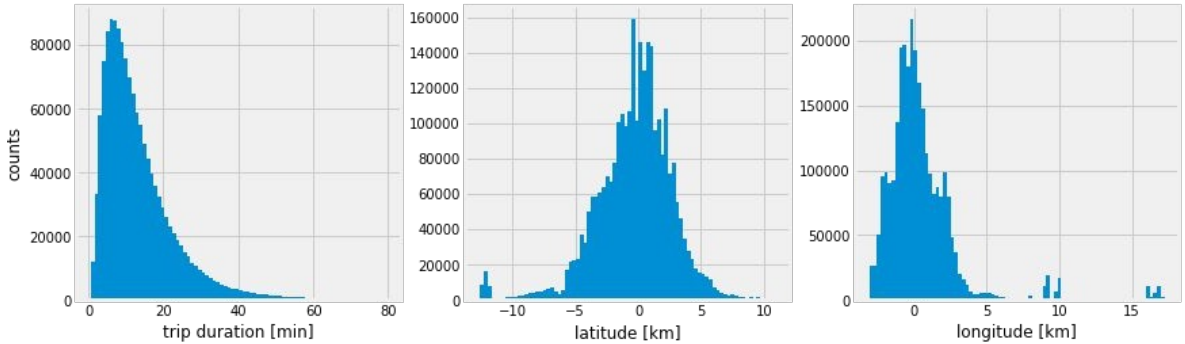


Pick-Up Times

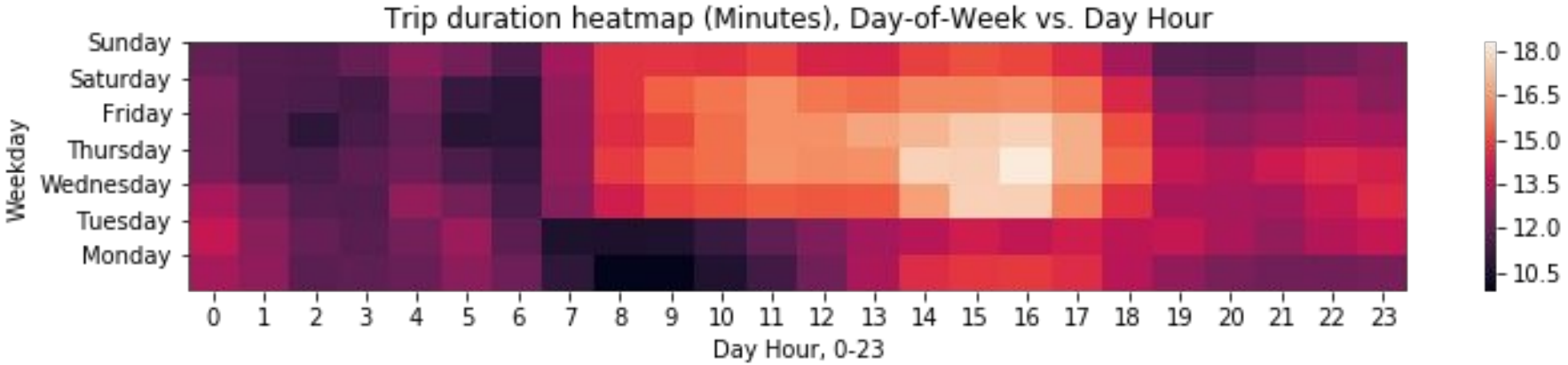


Trip Duration

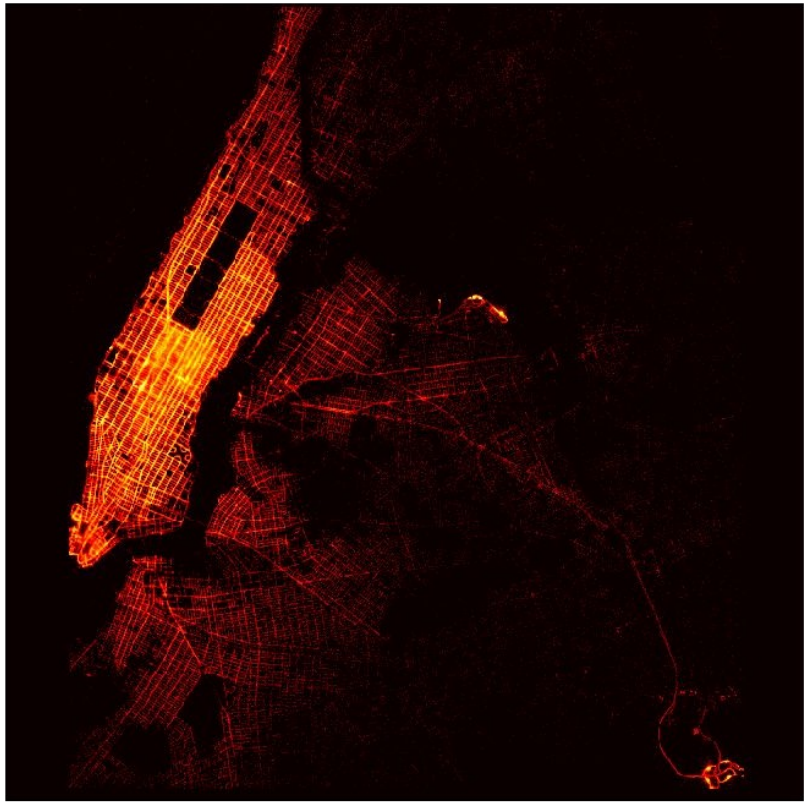


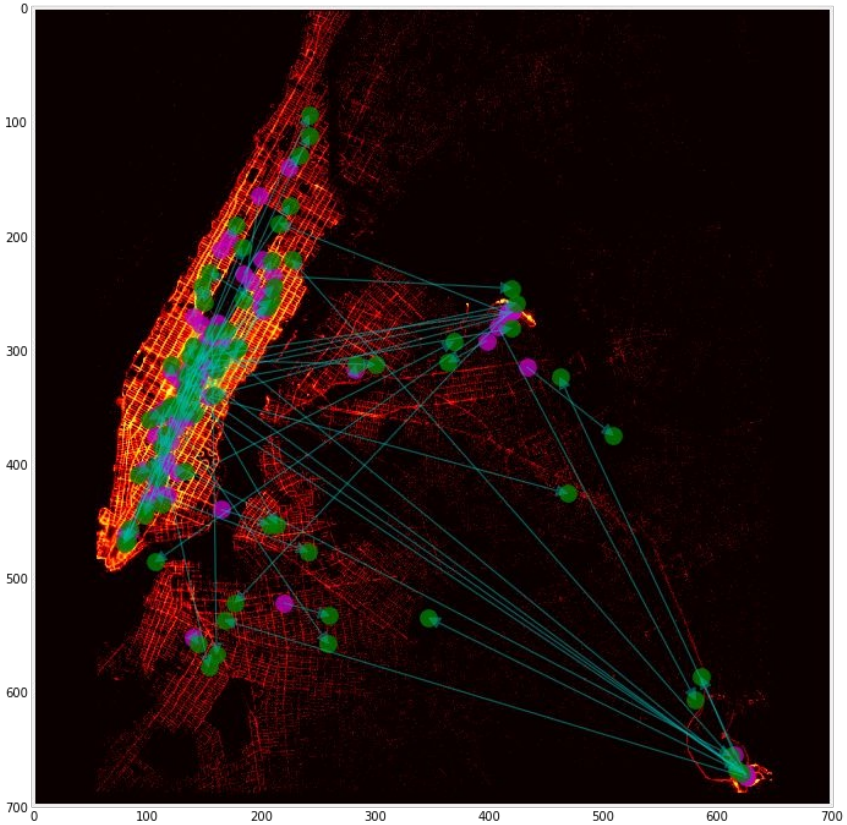


Trip Duration



Pickup and Dropoff Locations





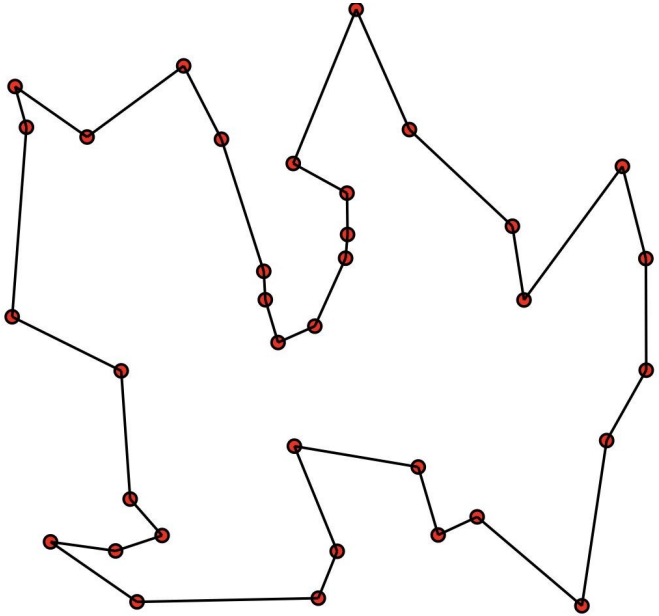
Machine Learning

- 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

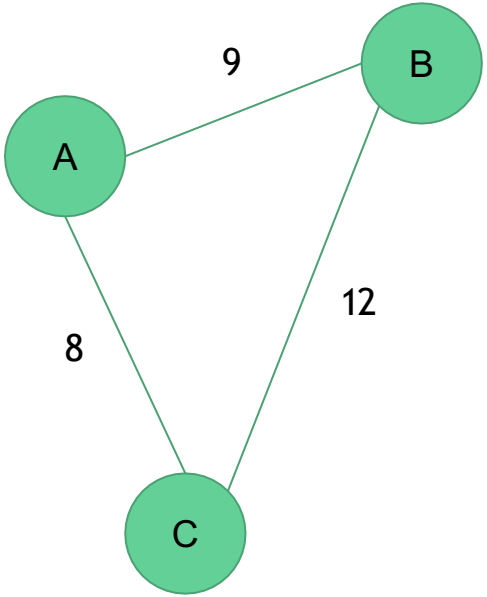
Ant Colony & Genetic Evolution Optimization

Traveling Salesman Problem (TSP)



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

Ant Colony Optimization



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

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

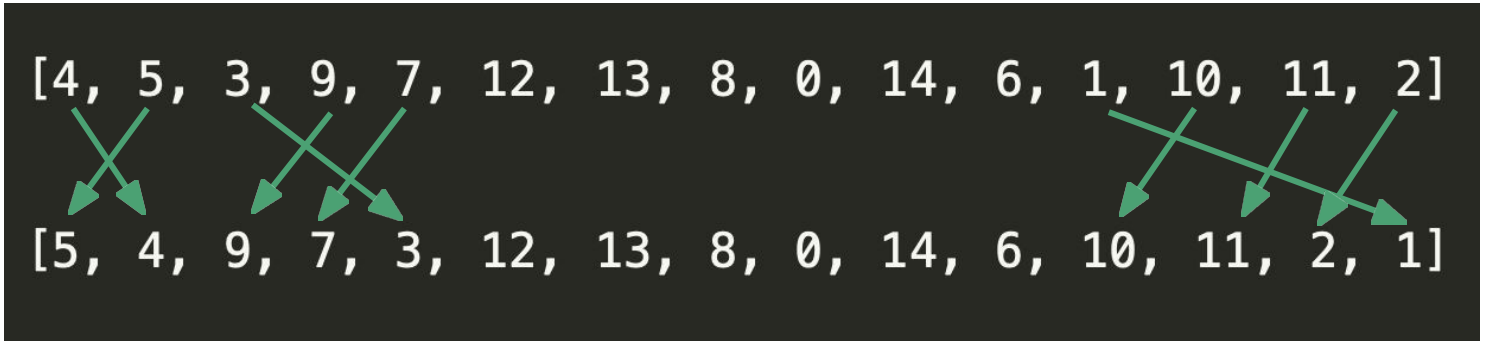
$$p_{ij} = \frac{[\tau_{ij}]^{\alpha} [\eta_{ij}]^{\beta}}{\sum_{h \in \mathcal{E}} [\tau_{ih}]^{\alpha} [\eta_{ih}]^{\beta}}$$

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]
```




```
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]
```

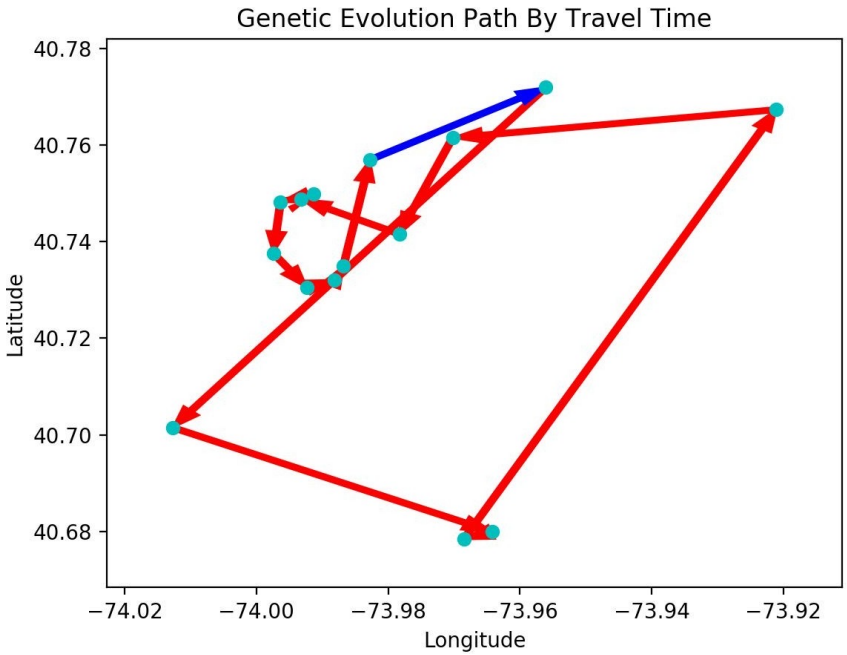
Evaluate Fitness

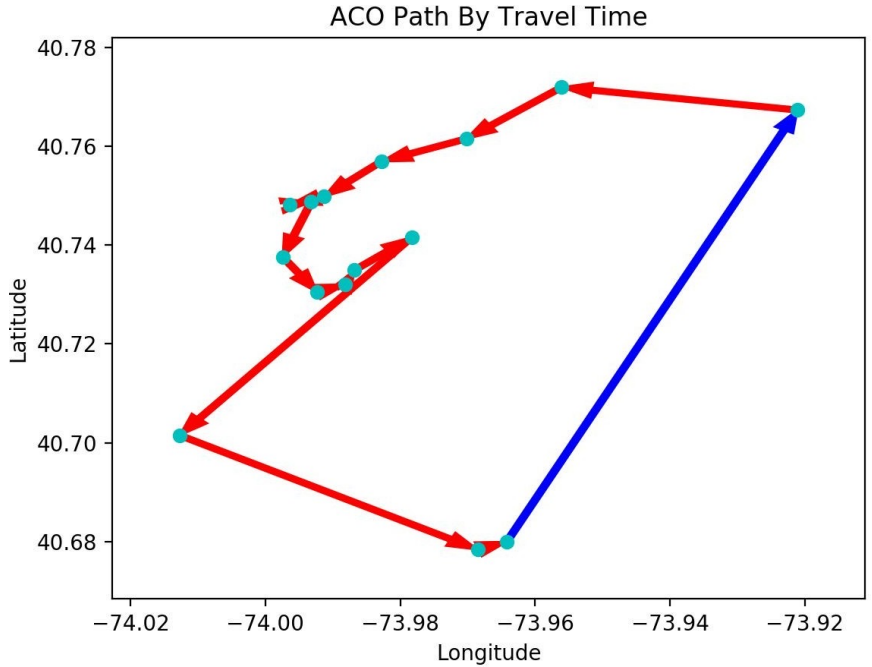
```
# Selection
# Select parent based on smaller path cost
candidate_cost = total_cost_from_path(candidate)
curr_cost = total_cost_from_path(curr_element)

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

Experimental Results

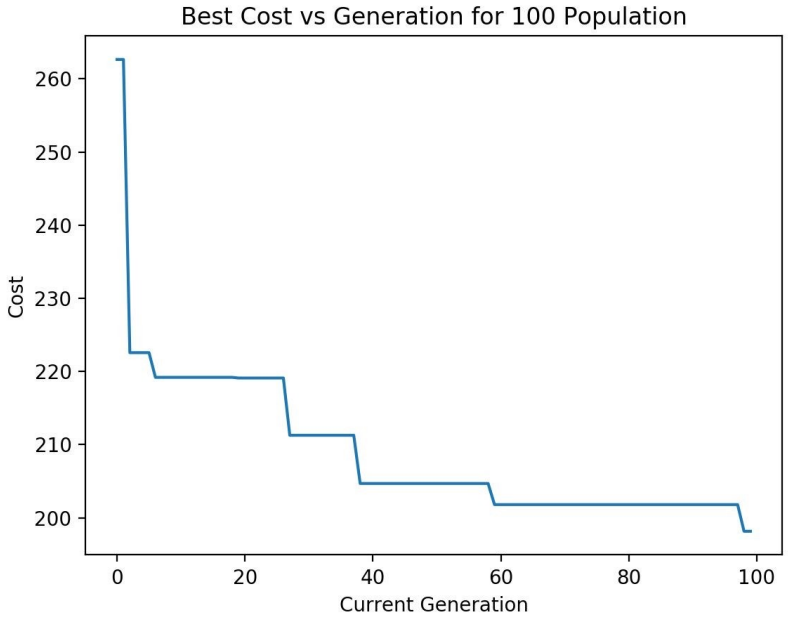
Ant Colony & Genetic Evolution Optimization

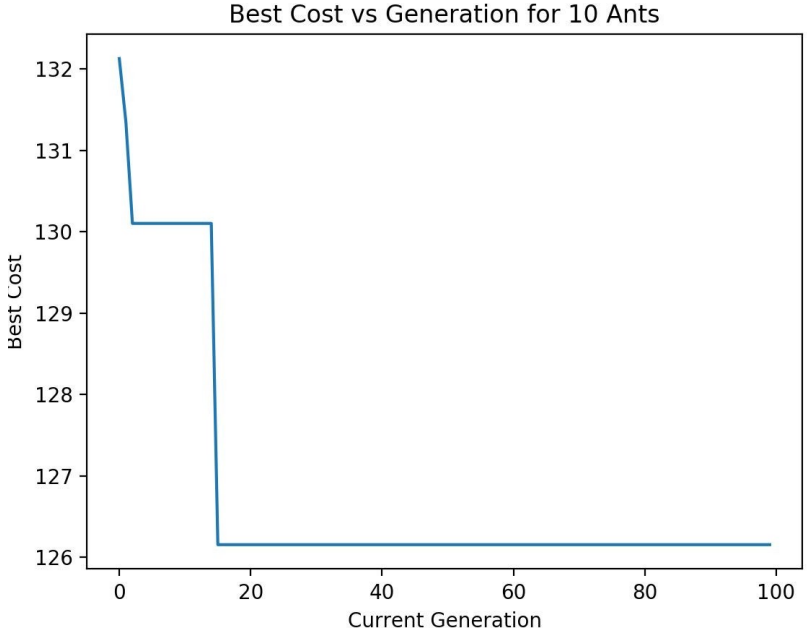
Generated Optimal Paths



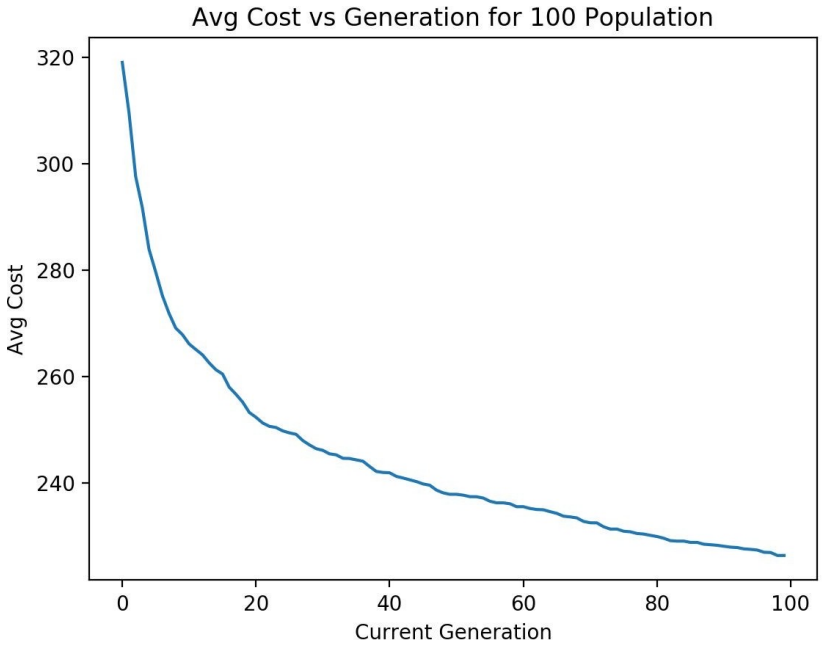


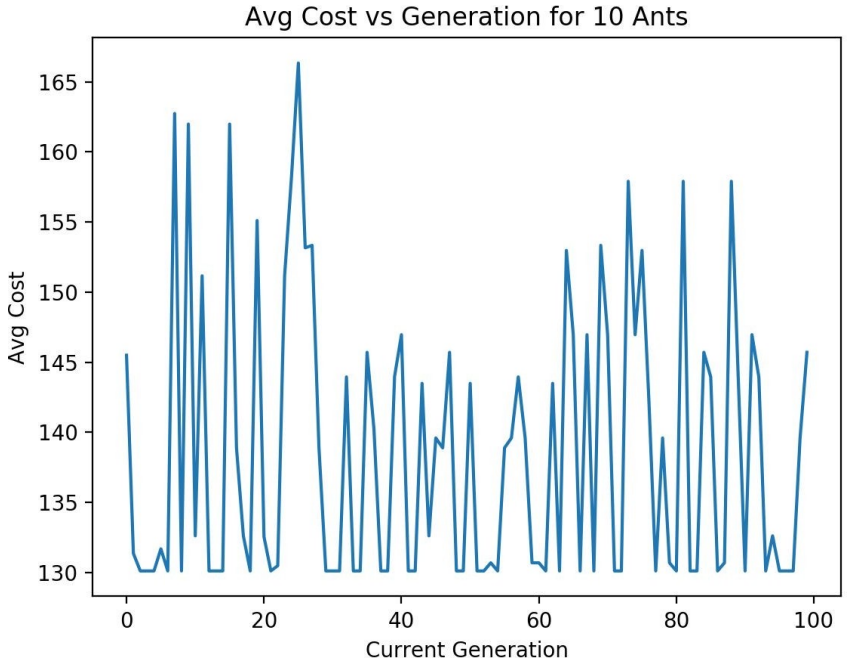
Optimal Cost Per Generation



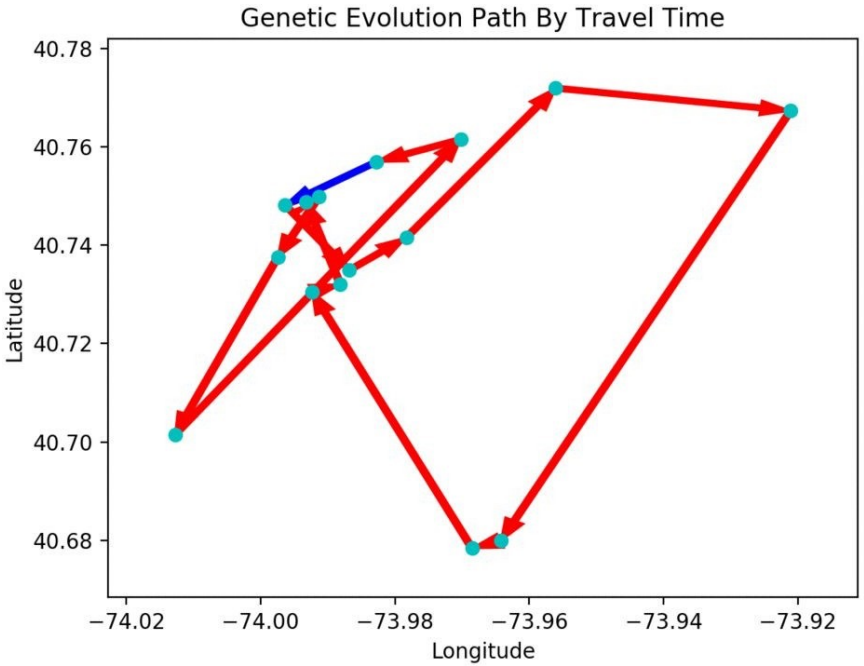


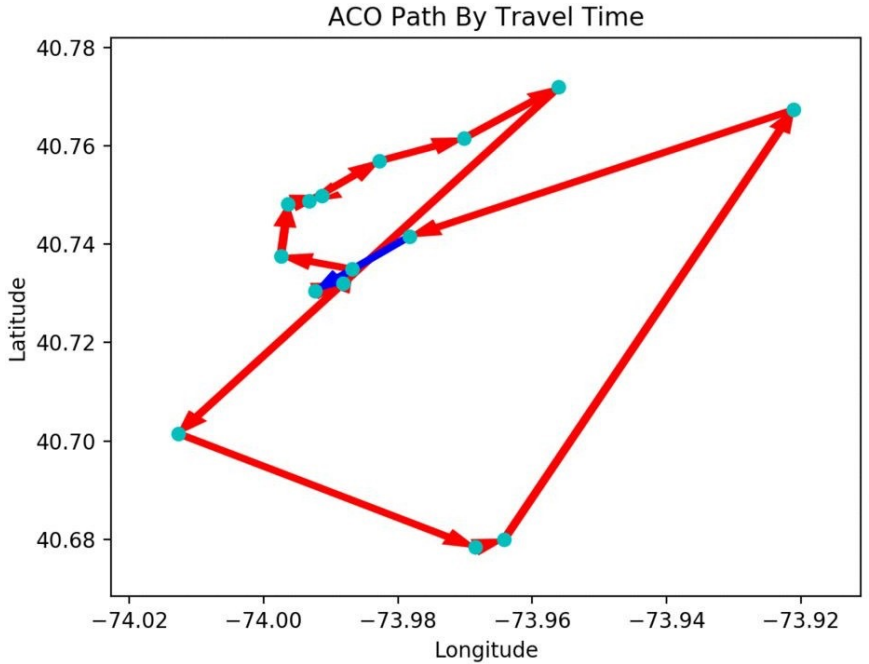
Average Cost Per Generation





Generated Paths



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3 DAYS TO KILL