

# Mandatory assignment 1: Traveling Salesman Problem

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## 1 Introduction

Brief explanation of the assignment, how to start the programs

## 2 Exhaustive search

Start the program with

```
$ python3 Exhaustive.py european_cities.csv
```

The program will find the shortest tour between 6 - 10 cities. The program outputs

```
For n_cities = 6:  
Best distance: 5018.8099999999995  
Best sequence: (0, 1, 4, 5, 2, 3)  
Best order of travel: Barcelona Belgrade Bucharest Budapest Berlin  
Brussels Barcelona
```

```
For n_cities = 7:  
Best distance: 5487.889999999999  
Best sequence: (2, 6, 3, 0, 1, 4, 5)
```

Best order of travel: Berlin Copenhagen Brussels Barcelona Belgrade  
Bucharest Budapest Berlin

For n\_cities = 8:  
Best distance: 6667.489999999999  
Best sequence: (3, 7, 0, 1, 4, 5, 2, 6)  
Best order of travel: Brussels Dublin Barcelona Belgrade Bucharest  
Budapest Berlin Copenhagen Brussels

For n\_cities = 9:  
Best distance: 6678.549999999999  
Best sequence: (2, 6, 8, 3, 7, 0, 1, 4, 5)  
Best order of travel: Berlin Copenhagen Hamburg Brussels Dublin  
Barcelona Belgrade Bucharest Budapest Berlin

For n\_cities = 10:  
Best distance: 7486.309999999999  
Best sequence: (6, 8, 3, 7, 0, 1, 9, 4, 5, 2)  
Best order of travel: Copenhagen Hamburg Brussels Dublin Barcelona  
Belgrade Istanbul Bucharest Budapest Berlin Copenhagen

Time spent[seconds]: [0.002037, 0.015967, 0.134317, 1.310069,  
13.964733]

The time used by the algorithm to find the best distance was measured. The time spent on solving TSP for six, seven, eight, nine and ten cities is shown in the last two lines of the program output and in figure 1.

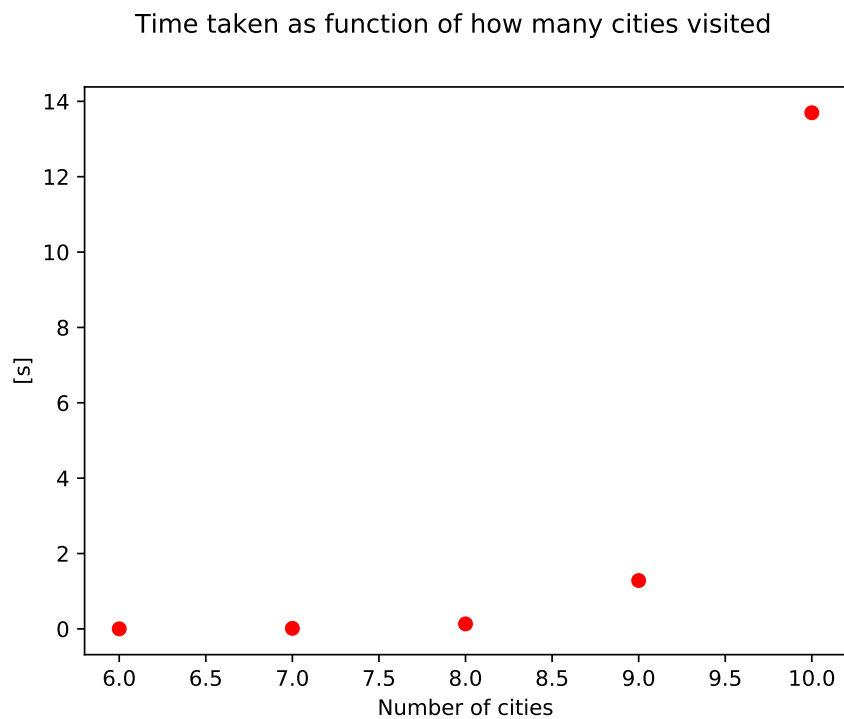


Figure 1: Time spent for the TSP algorithm

It can be seen that the time spent by the algorithm searching the TSP for  $n$  cities is roughly the time spent on calculating with  $n-1$  cities multiplied by  $n$ . The time spent by the algorithm to search TSP for 24 cities can be calculated with

$$t_{10} \frac{24!}{10!} \approx 14s \cdot \frac{24!}{10!} \approx 2.4 \cdot 10^{18}$$

### 3 Hill Climbing

Compare with exhaustive for 10 cities, run algorithm 20 times, report best worst mean and standard deviation for 10 runs and 24 runs

### 4 Genetic algorithm

Report parameters used, report best worst mean and deviation of 20 runs with three different values for population size, plot of average fitness of best individual of each run

## 5 Hybrid algorithm

Use hill climber on each individual as part of the evaluation, report min max mean deviation and average fitness with both Lamarckian and Baldwinian learning models, Compare result with GA