Optimization laboratory: Traveling Salesman Problem

Léa Ricard

Transport and Mobility Laboratory
School of Architecture, Civil and Environmental Engineering
École Polytechnique Fédérale de Lausanne

18 April 2024

Laboratory schedule

Date	Topic
18.04.2024	Optimization laboratory
25.04.2024	Multi-objective laboratory
	Optimization project
02.05.204	Optimization project
09.05.204	Optimization project
23.05.204	Optimization project

1. Problem definition - Traveling Salesman Problem (TSP)

2. TSP Exercises

3. My results

Traveling Salesman Problem (TSP)

Problem definition:

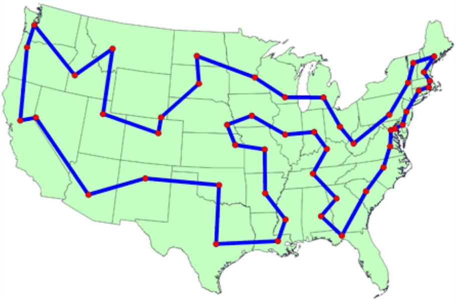
- A salesman must visit n cities.
- Every city must be visited exactly once.
- The salesman starts and ends the trip at their home city.
- The total trip length is assumed to be the cost of the travel.

Objective

- What sequence of cities minimizes the travel cost?

Traveling Salesman Problem (TSP)

- Applications:
    - Vehicle routing;
    - Job shop scheduling;
    - Computer wiring;
    - Etc.
- Largest instance solved by Concorde's TSP solver: 85,900 cities.



Traveling Salesman Problem (TSP)

Problem encoding

We consecutively number the cities: $0, 1, ..., n$.
We encode the solutions as $x = (x_0, x_1, ..., x_n, x_0)$ where

- x_0 is the index of the home city,
- x_i is the index of the i^{th} city visited along the way, and
- x_n is the index of the last city visited before returning home.

1. Problem definition - Traveling Salesman Problem (TSP)
2. TSP Exercises
3. My results

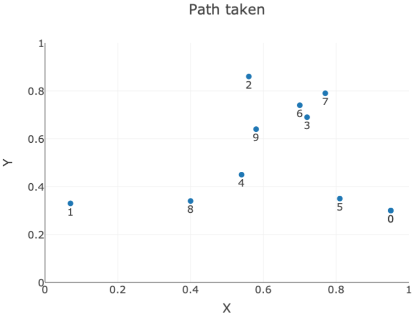
Implementation functions

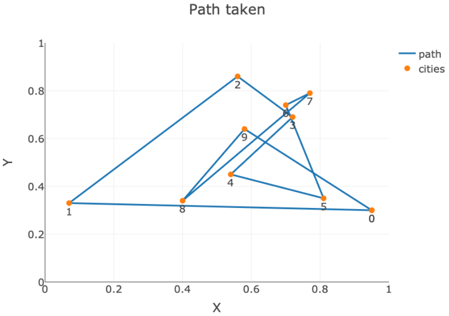
Core functionality

simulate_cities(seed, n_cities)

draw_salesman(path, cities)

evaluate_city_sequence(path, cities) → Calculate the total distance traveled





Algorithms to implement

Full enumeration:

- Understand its limitations

Optimization algorithms:

- Greedy algorithm
- Local search
- Variable neighborhood search
- Simulated annealing

IMPORTANT

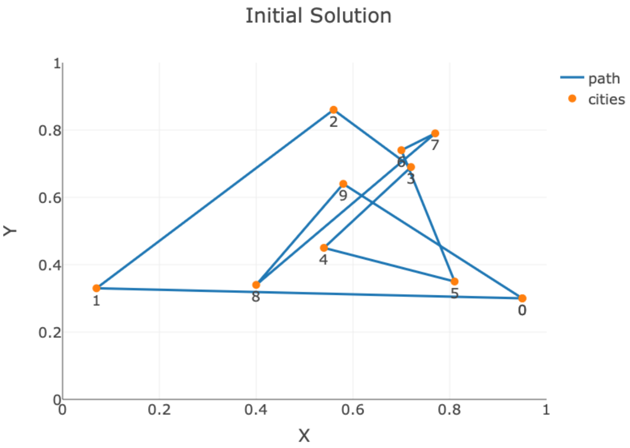
- The suggested framework is only a **suggestion**!
- Feel free to organize the code in the manner you find the most appropriate!

1 Problem definition - Traveling Salesman Problem (TSP)

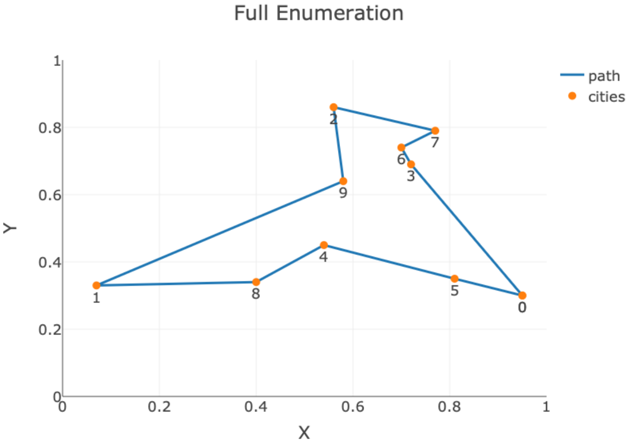
2 TSP Exercises

3 My results

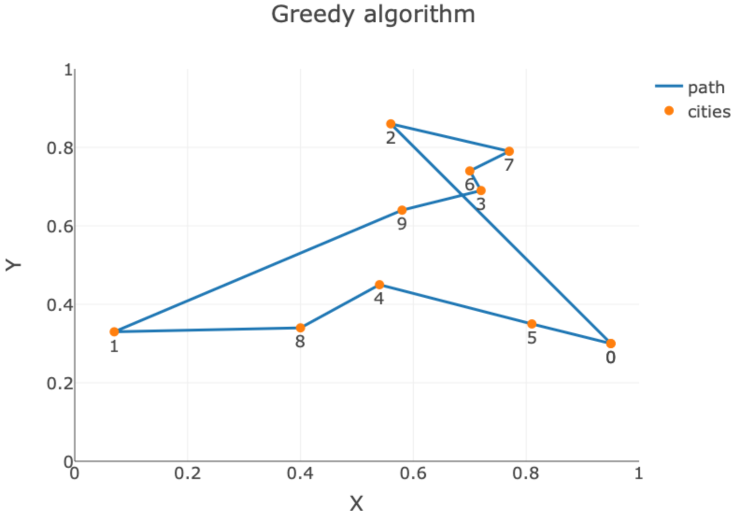
My results - An initial solution



My results - Full enumeration



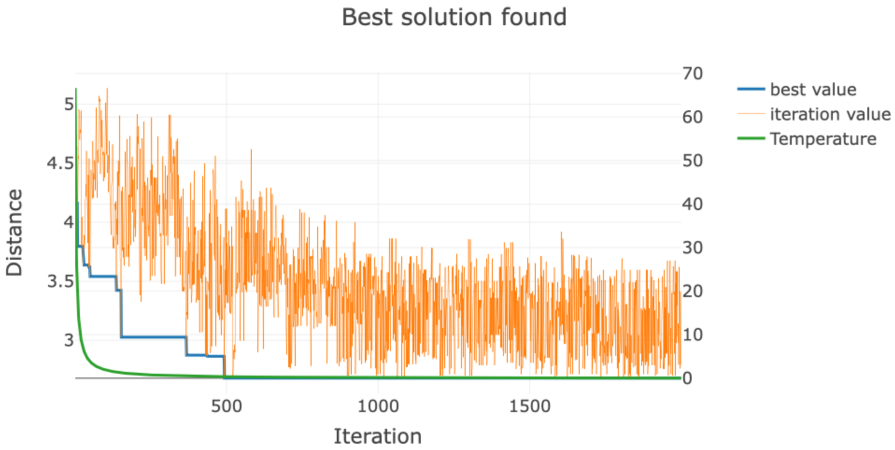
My results - Greedy algorithm



My results - Local search (LS), variable neighborhood search (VNS), and simulated annealing (SA)

- Same solutions as full enumeration (optimal).
- Computing time for instances with 10 cities and using the parameters specified for the SA algorithm: $\mathrm{CPU}_{\mathrm{LS}} < \mathrm{CPU}_{\mathrm{VNS}} < \mathrm{CPU}_{SA}$.

My results - Simulated annealing


Best solution found
Distance
Iteration
best value
iteration value
Temperature